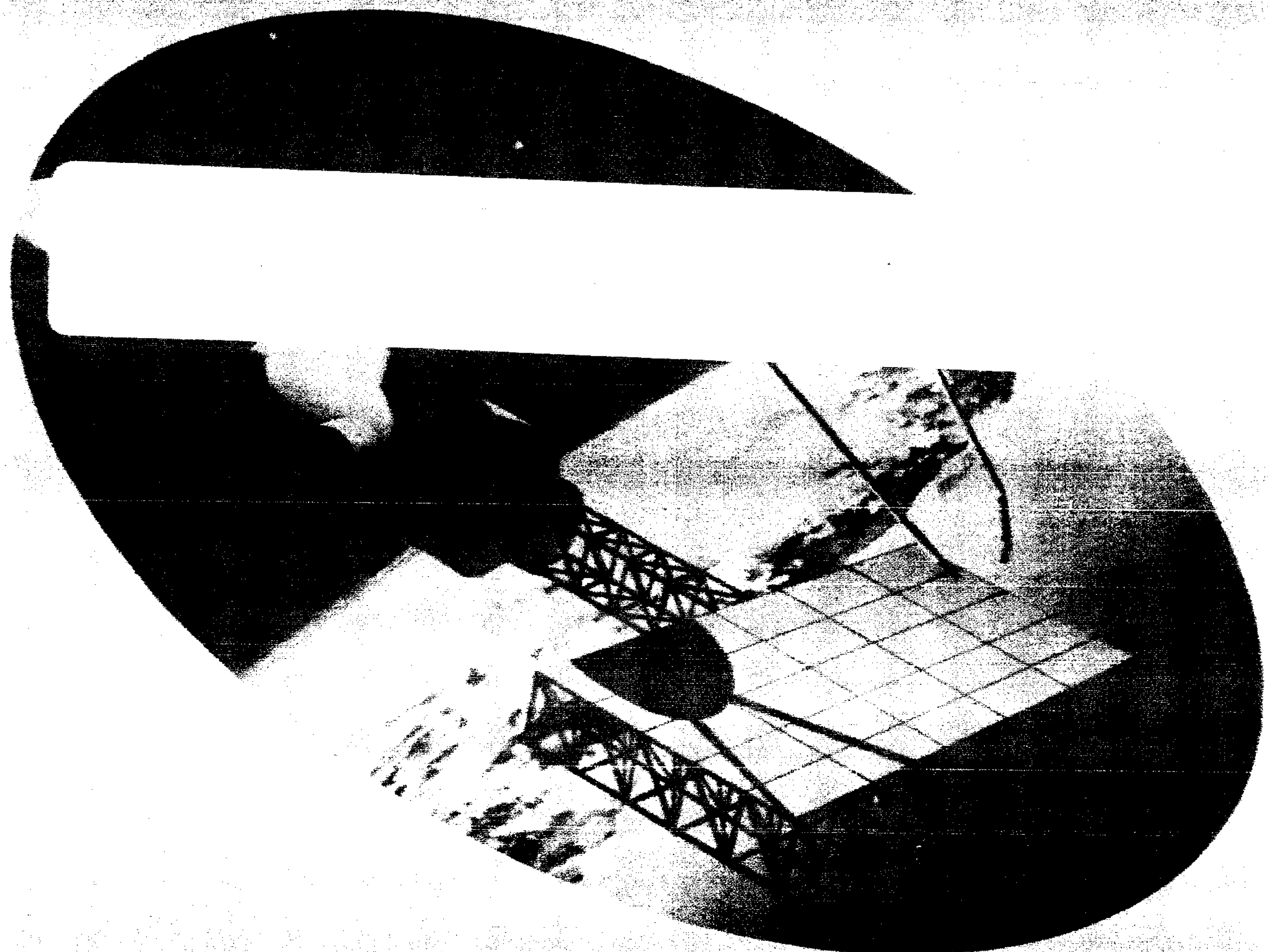
IN-SPACE RESEARCH, TECHNOLOGY AND ENGINEERING (RT&E) WORKSHOP

VOLUME 2 OF 8

SPACE STRUCTURE (DYNAMIC & CONTROL)



NATIONAL CONFERENCE CENTER
WILLIAMSBURG, VIRGINIA
OCTOBER 8-10, 1985

NASA
National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

OAST
Office of Aeronautics
and Space Technology
Washington, DC

NOTICE

The results of the OAST Research, Technology, and Engineering Workshop which was held at the National Conference Center, Williamsburg, Virginia, October 8-10, 1985 are contained in the following reports:

VOL 1	Executive Summary
VOL 2	Space Structure (Dynamics and Control)
VOL 3	Fluid Management
VOL 4	Space Environmental Effects
VOL 5	Energy Systems and Thermal Management
VOL 6	Information Systems
VOL 7	Automation and Robotics
VOL 8	**In-Space Operations**

Copies of these reports may be obtained by contacting:

NASA Langley Research Center
Attn: 288/Dr. Roger A. Breckenridge
Hampton, VA 23665

Commercial Telephone: (804) 865-4834
Federal Telephone System: 928-4834

SPACE STRUCTURE (DYNAMICS AND CONTROL)

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FOREWORD

Within NASA, the Office of Aeronautics and Space Technology (OAST) has the responsibility for timely development of needed new technologies. Traditionally, the development of new concepts, new materials, designs, and engineering techniques for aeronautics has been accomplished in close cooperation with the aircraft industry and with the great American universities. On the other hand, NASA, as the primary user of space flight, has been its own principal customer for new space technologies.

A new era of permanent presence in space is beginning with the Space Station. This permanent presence will permit and promote commercial ventures and privately funded research in the tradition of university/industry cooperation.

The RT&E workshop in Williamsburg represents a significant milestone for NASA and the space engineering community. It marked the initiation of a long-term program of outreach by NASA to focus the needs of universities, industry, and government for in-space experiments and to begin building a strong national user constituency for space research and engineering.

These proceedings represent a "first-cut" planning activity to involve universities, industry, and other government agencies with NASA to establish structure and content for a national in-space RT&E program. More interactions are needed - more workshops will follow. Program adjustments will be made. A truly national program will evolve, and its beginnings are presented here with the hope and determination needed to make it a program we can all take pride in.

- Raymond Colladay

INTRODUCTION

Among the purposes of the Research, Engineering, and Technology Workshop, an interest in validating the RT&E theme concept has some direct effect on the form of these proceedings. The original five themes, which were themselves a target for validation or recommeded changes, have become seven. During preparations for the workshop, the submitted papers and attendance plans made it evident that the fifth "theme", In-space Operations, was too broad, and would need to be split. As the workshop got underway, a further split occurred, brought about by the different levels of maturity, and needs for technology planning in several sub-disciplines. Thus, these proceedings are presented under seven themes. The volume of presentations, and the quantity of information generated by the individual panel summaries has led to the decision to prepare the proceedings in several volumes.

The first volume is an executive summary and includes the summary presentations made by the panel co-chairmen in the final plenary session. The accompanying seven volumes, of which this is one, each represent a specific "theme", and include the un-edited original presentation material used in that particular panel workshop. Each of these separate "theme" volumes also include the Foreword, the general Summary and Conclusions, and the Chairman's presentation charts and narrative summary. Thus, each should represent a self-standing volume to reflect the proceedings relevant to its respective Panel deliberations and output, as well as the reflection in the general Workshop results.

WORKSHOP THEME

Space Structure (Dynamics and Control)

--Advanced Structural Concepts

--Structural Dynamics

--Advanced Control Concepts

--Structure/Control Interaction

--Structure/Control Sensors

SUMMARY AND CONCLUSIONS

NASA's In-Space Research, Technology, and Engineering (RT&E) Workshop brought together representatives of the university community, private sector, and government agencies to discuss future needs for in-space experiments in support of space technology development and the derivative requirements for space station facilities to support in-space RT&E.

The workshop provided an excellent forum for establishing an interactive process for building a national in-space experiments program. It enabled NASA to present to the user community (university and private sector) experiment concepts for NASA's technology development activities in support of future space missions. The meetings also began a process by which industry and university researchers will be able to bring their own TDM requirements to NASA's planning process.

This conference reached three primary goals: first, it expanded and validated NASA's in-space experiment theme areas, including Space Structure (Dynamics and Control), Space Environmental Effects, Fluids Management, Energy Systems and Thermal Management, Automation and Robotics, Information Systems and In-Space Operations; second, it began the development of a user community network which will interface with NASA throughout the lifetime of the in-space experiment program; and third, it formed the basis for the establishment of on-going working groups which will continue to interest and coordinate requirements for in-space RT&E activities.

As an adjunct to the conference, NASA/OAST announced plans to initiate a long-term program to encourage and support industry and university experiments. NASA's modest investment in this program is initially targeted for generating experiment ideas and concepts. It is anticipated that this base of concepts will lead to cooperatively funded experiments between NASA, industry, and academia and thereby, begin to build an active in-space RT&E program.

Several key points emerged from this conference regarding the adequacy of the TDM data base that should be addressed in future planning activities. First, many of the experiments could be performed on the ground, i.e., they do not justify a space experiment. Secondly, many of the experiments address near-term or current applications and do not take into account advanced system requirements. The TDM data base must look beyond extensions of current programs to reflect future needs and trends to have an effective and useful impact on space station planning and design. This will require increased input from industry and university researchers and engineers.

In order to address these concerns, it is imperative that a long-range planning view be taken in which industry and university researchers help NASA derive the technology development program. The following recommendations have been developed on the basis of the workshop:

1. Development of an on-going RT&E university and industry advisory group;
2. Continuation of in-space RT&E symposia to act both as outreach mechanisms and as working sessions to refine the TDM data base;
3. Development of an RT&E information clearinghouse;
4. Development and continuation of the new experiments outreach activity announced at the RT&E workshop;
5. Development of an "impacts assessment group" which will focus its energy on identifying experiment accommodation requirements to impact the design of in-space facilities, i.e., space station and others.

If carried out, these recommendations constitute movement toward development of an effective NASA/industry/university partnership in a National In-Space RT&E Program. This will also enable NASA/OAST to have an effective voice in space station planning, which is essential toward the success of a future in-space activities. The workshop, by promoting the process of NASA/industry/university interactions and by pointing out concerns with the developing TDM data base has provided an important first step towards a successful long-term space technology development effort.

IN-SPACE RESEARCH, TECHNOLOGY, AND ENGINEERING WORKSHOP

SPACE STRUCTURE (DYNAMICS AND CONTROL)

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SPACE STRUCTURE
(DYNAMICS AND CONTROL)
SUMMARY

Samuel L. Venneri

The experiments presented to the panel were under five key technology areas as follows:

1. COMPONENT TECHNOLOGY
   - SENSORS
   - ACTUATORS

2. - CONTROL STRUCTURE INTERACTION
   - CONTROL TECHNOLOGY
   - STATION KEEPING
   - MANEUVERS
   - POINTING

3. SPACE STATION DYNAMIC CHARACTERIZATION
   - DYNAMIC MODELLING

4. SPACE STATION CONSTRUCTION TECHNOLOGY
   - MATERIAL BEHAVIOR
   - ASSEMBLY
   - DEPLOYMENT

5. - ADVANCED STRUCTURAL CONCEPTS

To identify technology gaps in the proposed experiments, an experiment/technology matrix was formed for all the experiments proposed. The experiment/technology matrices plus member opinions were used to develop a list of technology gaps. The Committee felt that validation of proposed Space Station IOC structure, including construction techniques, utility integration, and long-term integrity was not adequately addressed. The use of passive damping to solve Station vibration problems was lacking. No experiments involved with in-space loads characterization for the Station were proposed. Consideration of cost-effective hardware was not apparent in proposed experiments. Finally, efforts on structurally embedded sensors/actuators, vibration shape/control devices, and low-frequency isolators were inadequate.

Mass, power, and data requirements were modest. A few experiments required large deployed volumes which the Committee felt were not being addressed by Space Station.

The larger volume experiments gave rise to consideration of what impacts structures experiments might have on Space Station. The Committee felt that Space Station should accommodate the construction and structural testing of future large space systems. Problems induced by this activity were experiment-induced vibration disturbances, large volume envelopes in which to work, and design of an attitude control system to accommodate structural vibration tests. The Committee also felt that the Station design had not been adequately over-designed (scarred) to accommodate a structural development/test facility.

Experiments were examined to indicate their appropriateness for ground, Space Shuttle or Space Station. Originally, the panel had intended to make recommendations on suitability of experiments for ground or flight testirg; however, due to shortage of deliberation time and lack of evaluation criteria, the panel was unable to perform this task. Thus, only the sponsors' recommendations for time phasing are presented here.

It appeared that there was a strong interest in long-term durability of components. A Space Station component test facility seemed to be appropriate for such long-term testing activities.

The Actively-Controlled Instrument-Support Truss is an experiment proposed by GSFC to develop technology for platforms which have demanding precision requirements to support multiple instruments. On the Space Station, it is likely that there will be many Control/Structures Interactions experiments including large antennas and robotic or articulated structures. As mentioned previously, the development and test of such structures has significant impact on Space Station design and control.

The Space Station itself can be used as a flight experiment during IOC development and evolution. It would be desirable to have ongoing developments of nondestructive evaluation techniques to monitor the structural health of the Space Station. A longer range problem that needs basic technology is fluid-structure interaction experiments. The Station is expected to have numerous storage tanks of fluids, and the basics of sloshing and dynamic forcing function from fluid dynamics must be understood.

As the Station is constructed, dynamic measurements of its response should be made to confirm math models used in design. A life assessment system could also be installed during this period. After construction, the Station also can be used as a test bed for advanced control experiments. As the Station evolves, the growth Station dynamics can be estimated from growth math models validated by ground tests of a growth Station dynamic model and by selected experiments on Station. For example, components of growth solar dynamics rotating machinery or tank slosh baffles could be evaluated.

To determine the most practical construction technique for Space Station, experiments are ongoing in ground-based neutral buoyancy facilities. NASA's first space construction experiments (ACCESS/EASE) are scheduled for this year. The Committee recommended follow-on Space Station Construction Validation Experiments to ensure that procedures for erection, deployment, and utility integration could be validated. Once the Station was constructed, it would be available as a construction bed on which to assemble large antennas, platforms, and advanced orbital transfer vehicles.

The Committee felt there was a lack of advanced structural concepts for space construction. More effort is needed on design and ground tests of advanced concepts for making structural surfaces, elements and joints, for providing protection from debris and for developing advanced large antennas. Once the Station is operational, it was anticipated that numerous opportunities for making structures in-space might be conceived.

To further encourage development, by industry, the Committee identified critical elements for development. The list below shows sensor, actuator, and computer technology needed for future experiments.

- o High Accuracy Surface Sensor (Multi DOF)
- o Real-Time Photogrametric Concept
- o Mid-Range Momentum Actuators
- o High Speed, High Capacity Flight Computers for CSI
- o High Speed, High Capacity Data Bases

- o Multi-Body Alignment Transfer & Pointing System
- o Relative Alignment Sensor
- o Vibration Actuators
- o Low-Frequency Actuators
- o Optical/Inertial Vibration Sensors
- o Low-G Accelerometer
- o Low-Thruster for Reboost

Because of costs, the Committee felt that it was important to have criteria to measure the value of conducting experiments in space versus on earth. Many of the experiments presented at the workshop were in partial stages of development, and a framework was needed to perform objective screening. Teaming of industry, universities, and NASA should strengthen the creativity and cost-effectiveness of proposed experiments. Finally, a management issue for NASA is to alleviate Shuttle and Space Station integration overhead which is a formidable obstacle to experimenters in universities, industry, and NASA.

NASA should establish a formal review committee for structures, dynamics and control experiments. The committee should quantify IOC Station requirements to ensure that future experiments can be accommodated. It should establish criteria to assist experiment selection and prioritization, and investigate methods to simplify experiment integration. If such a committee existed, the need for future workshops might be questionable, and we could get on with the job of developing a set of affordable and needed Station experiments.

STRUCTURES DYNAMICS AND CONTROL

- o KEY TECHNOLOGIES
- o GAPS IN PROPOSED EXPERIMENTS
- o CAPABILITIES REQUIRED ON STATION
  - KEY SUPPORT REQUIREMENTS
- o TIME PHASING
  - TECHNOLOGIES
  - CAPABILITIES
  - EXPERIMENTS
- o JOINT EFFORT OPPORTUNITIES
- o EXPERIMENTAL PROGRAM ISSUES

Figure 2

KEY STRUCTURES DYNAMICS AND CONTROL TECHNOLOGIES

1. COMPONENT TECHNOLOGY
   - SENSORS
   - ACTUATORS
2. CONTROL STRUCTURE INTERACTION
   - CONTROL TECHNOLOGY
   - STATION KEEPING
   - MANUEVERS
   - POINTING
3. SPACE STATION DYNAMIC CHARACTERIZATION
   - DYNAMIC MODELLING
4. SPACE STATION CONSTRUCTION TECHNOLOGY
   - MATERIAL BEHAVIOR
   - ASSEMBLY
   - DEPLOYMENT
5. ADVANCED STRUCTURAL CONCEPTS

Figure 3

EXPERIMENT/TECHNOLOGY MATRIX	Deployment Dynamics	Dynamic Modeling	Articulated Multibody Dynamics	Joint Modeling	Damping Models	Tether Dynamics	Structural Mat'l (Protective Coa	Passive Damping	Long Life Materials	Environmental Modeling	Disturbance Characterization	Structural Concepts	Low Cost Concepts	ORU Concepts	Integrated Structure/Control	Integrated Sensors				
1. Component Tech. 1. Fiber Optic Sensors - In-Space Appl.																				
2. S/C Strain and Acoustic Sensors																				
3. Docking Sensor																				
4. Attitude Control & Energy Flight Experiment																				
5. Advanced Control Device Technology																				
6. Thermal Shape Control																				
7. Material Durability for Traction Drive									X											
8. Advanced Expt. Pointing and Isolation																				

Figure 4(a)

EXPERIMENT/TECHNOLOGY MATRIX	Attitude Control Devices	Alignment Sensors	Structural Control Actuators	Inertial Sensors	Berthing/Docking Sensors	Shape/Configuration Sensors	Precision Stationkeeping	High Accuracy Pointing Devices	Alignment Techniques	System Identification	Maneuvering Techniques	Orbital Assembly	Test & Verification Sensors	Disturbance Suppression	Articulated System Control	Active Modal Control	Adaptive Control	Shape Control	Distributed Control	Multi-Loop Control	Hierarchical Control
1. Component Tech																					
1. Fiber Optic Sensors - In-Space Appl.				X		X															
2. S/C Strain and Acoustic Sensors						X															
3. Docking Sensor				X																	
4. Attitude Control & Energy Flight Experment	X																				
5. Advanced Control Device Technology	X																				
6. Thermal Shape Control		X																X			
7. Material Durability for Traction Drive																					
8. Advanced Expt. Pointing and Isolation								X													

Figure 4(b)

EXPERIMENT/TECHNOLOGY MATRIX	Attitude Control Devices	Alignment Sensors	Structural Control Actuators	Inertial Sensors	Berthing/Docking Sensors	Shape/Configuration Sensors	Sensors for Precision Stationkeeping	High Accuracy Pointing Devices	Alignment Techniques	System Identification	Maneuvering Techniques	Orbital Assembly	Test & Verification Sensors	Disturbance Suppression	Articulated Control System	Active Modal Control	Adaptive Control	Shape Control	Distributed Control	Multi-Loop Control	Hierarchical Control
2. **Control/Struc. Interac. Expts.**																					
1. COFS Flight Expts.									X	X	X		X		X	X	X	X	X		
2. Flight Dynamics Identification									X												
3. Dynamic Disturbance Control									X	X		X	X	X			X				
4. Distributed Control Experiment									X				X	X							
5. Advanced Adaptive Control									X				X		X						
6. Platform Active Control		X	X														X	X			

Figure 5(a)

EXPERIMENT/TECHNOLOGY MATRIX	Deployment Dynamics	Dynamic Modeling	Articulated Multibody Dynamics	Joint Modeling	Damping Modeling	Tether Dynamics	Structural Materials (Protective Coatings)	Passive Damping	Long Life Materials	Environmental Modeling	Disturbance Characterization	Structural Concepts	Low Cost Concepts	ORU Concepts	Integrated Structure/Control	Integrated Sensors				
2. Control/Struc. Interac. Expts.																				
1. COFS Flight Expts.	X	X																		
2. Flight Dynamics Identification		X																		
3. Dynamic Disturbance Control		X	X																	
4. Distributed Control Experiment		X	X																	
5. Advanced Adaptive Control		X	X																	
6. Platform Active Control		X													X					

Figure [illegible]

EXPERIMENT/TECHNOLOGY MATRIX	Attitude Control Devices	Alignment Sensors	Structural Control Actuators	Inertial Sensors	Berthing/Docking Sensors	Shape/Configuration Sensors	Precision Stationkeeping	High Accuracy Pointing Devices	Alignment Techniques	System Identification	Maneuvering Techniques	Orbital Assembly	Test & Verification Sensors	Disturbance Suppression	Articulated System Control	Active Modal Control	Adaptive Control	Shape Control	Distributed Control	Multi-Loop Control	Hierarchical Control
3. Space Station Dynamic Characterization																					
1. Space Station Performance Technology Validation										X			X								
2. Advanced Controls Technology										X						X		X			

Figure 6(b)

EXPERIMENT/TECHNOLOGY MATRIX	Deployment Dynamics	Dynamic Modeling	Articulated Multibody Dynamics	Joint Modeling	Damping Models	Tether Dynamics	Structural Matr (Protective Coa.	Passive Damping	Long Life Materials	Environmental Modeling	Disturbance Characterization	Structural Concepts	Low Cost Concepts	ORU Concepts	Integrated Structure/Control	Integrated Sensors					
4. <u>Space Const. Technology</u> 1. Advd. Antenna Assem./Perform	X	X																			
2. Precision Optical																					
3. On-Orbit S/C Assembly/Test						X								X							
4. Space Validation of Underwater Testing																					
5. Large Space Antenna	X	X																			
6. Large Space Structure	X	X																			
7. Space Station Modifications																					
8. Structural Assembly Experiments																					

Figure 7(a)

EXPERIMENT/TECHNOLOGY MATRIX	Attitude Control Devices	Alignment Sensors	Structural Control Actuators	Inertial Sensors	Berthing/Docking Sensors	Shape/Configuration Sensors	Precision Stationkeeping	High Accuracy Pointing Devices	Alignment Techniques	System Identification	Maneuvering Techniques	Orbital Assembly	Test & Verification Sensors	Disturbance Suppression	Articulated System Control	Active Modal Control	Adaptive Control	Shape Control	Distributed Control	Multi-Loop Control	Hierarchical Control
4. Space Const. Technology 1. Advd. Antenna Assem./Perform										X		X									
2. Precision Optical										X		X			X				X	X	
3. On-Orbit S/C Assembly/Test												X	X								
4. Space Validation of Underwater Testing												X									
5. Large Space Antenna										X						X		X			
6. Large Space Structure												X									
7. Space Station Modifications												X									
8. Structural Assembly Experiments																					

Figure 7(b)

EXPERIMENT/TECHNOLOGY MATRIX	Deployment Dynamics	Dynamic Modeling	Articulated Multibody Dynamics	Joint Modeling	Damping Models	Tether Dynamics	Structural Mat./Protective Coa.	Passive Damping	Long Life Materials	Environmental Modeling	Disturbance Characterization	Structural Concepts	Low Cost Concepts	ORU Concepts	Integrated Structure/Control	Integrated Sensors				
5. Advd. Structural Concepts & Fabrication Technologies																				
1. Inflatable/ Rigidifable Structural Element	X						X		X			X								
2. Ion Beam Cold Welding							X													

Figure 8(a)

EXPERIMENT/TECHNOLOGY MATRIX	Attitude Control Devices	Alignment Sensors	Structural Control Actuators	Inertial Sensors	Berthing/Docking Sensors	Shape/Configuration Sensors	Precision Stationkeeping	High Accuracy Pointing Devices	Alignment Techniques	System Identification	Maneuvering Techniques	Orbital Assembly	Test & Verification Sensors	Disturbance Suppression	Articulated System Control	Active Modal Control	Adaptive Control	Shape Control	Distributed Control	Multi-Loop Control	Hierarchical Control
5. <u>Advd. Structural Concepts & Fabrication Technologies</u>																					
1. Inflatable/ Rigidifable Structural Element												X									
2. Ion Beam Cold Welding												X									

Figure 8(b)

TECHNOLOGY GAPS IN PROPOSED EXPERIMENTS

- VALIDATION OF STATION IOC CONSTRUCTION AND UTILITY INTEGRATION
- VALIDATION OF LONG-TERM STRUCTURAL INTEGRITY
- PASSIVE DAMPING
- IN-SPACE LOADS CHARACTERIZATION
- COST-EFFECTIVE HARDWARE DEVELOPMENT
- STRUCTURALLY-EMBEDDED SENSORS/ACTUATORS
- VIBRATION/SHAPE CONTROL DEVICES
  - SENSORS
  - ACTUATORS
- LOW-FREQUENCY ISOLATION DEVICES

Figure 9

SPACE STRUCTURE (DYNAMICS & CONTROL)
SPACE STATION RESOURCE ACCOMMODATION SUMMARY

TIME FRAME -

MOST EXPERIMENTS AVAILABLE BETWEEN 1992-1994, ALL BY 1997

MASS -

MOST EXPERIMENTS LESS THAN 500 KG
- 2 ARE 1500 KG TO 3000 KG
- 2 ARE 7,000 KG

VOLUME -

MOST REQUIRE LESS THAN 50 M^3 STORED VOLUME
NONE REQUIRE MORE THAN 300 M^3 STORED VOLUME

DEPLOYED VOLUME -

SEVERAL REQUIRE LARGE EXTERNAL VOLUME ENVELOPES 5,000 M^3 - 9,000 M^3

ATTACHMENT -

ALL REQUIRE EXTERNAL ATTACHMENTS

ORIENTATION

GENERALLY NOT AN ISSUE, FEW REQUIRE EARTH, SOLAR, INTERTIAL

POWER -

1.5 KW WILL ACCOMMODATE MOST EXPERIMENTS

DATA -

RATE - 1 MB/S WILL ACCOMMODATE MOST EXPERIMENTS
STORAGE - 1 G BIT WILL ACCOMMODATE MOST EXPERIMENTS

*LARC WILL GENERATE SYNTHESIZED MISSION REQUIREMENTS

IMPACT OF STRUCTURES EXPERIMENTS ON IOC SPACE STATION

- STATION MUST ACCOMMODATE EXPERIMENT - INDUCED DYNAMIC DISTURBANCE
- LOCATIONS MUST BE PROVIDED TO ACCOMMODATE EXPERIMENTS WITH LARGE VOLUME ENVELOPES
- ATTITUDE CONTROL SYSTEM MUST ACCOMMODATE LARGE STRUCTURAL EXPERIMENTS
  - FLEXIBLE STRUCTURES
  - LARGE MASS/INTERIAS
- IOC STATION DESIGN NEEDS TO BE "SCARRED" FOR STRUCTURAL DEVELOPMENT/TEST FACILITY
  - COMPONENT TECHNOLOGY
  - CSI EXPERIMENTS
  - SPACE CONSTRUCTION
  - ADVANCED STRUCTURAL FABRICATION

Figure 11

TIME PHASING OF EXPERIMENTS

EXPERIMENT	LOCATION					
	GROUND		SPACE			
			SHUTTLE		SPACE STATION	
	SPONSOR	PANEL	SPONSOR	PANEL	SPONSOR	PANEL
1. COMPONENT TECHNOLOGY						
SENSORS SPACECRAFT STRAIN AND ACOUSTIC SENSORS					1992	
FIBER OPTIC SENSORS IN-SPACE APPL.	X				1990	
BERTHING AND DOCKING SENSOR			1987/88			
ACTUATORS						
ATTITUDE CONTROL AND ENERGY EXPERIMENT	X				1992	
ADVANCE CONTROL DEVICE TECHNOLOGY	X				1994	
THERMAL SHAPE CONTROL	X				1992	
TRIBOLOGY						
MATERIAL DURABILITY FOR TRACTION DRIVE					1989	
PROCESSORS						
MECHANISMS						
ADVANCED EXPERIMENT POINTING AND ISOLATION DEVICE					1992	

Figure 12(a)

TIME PHASING EXPERIMENTS

EXPERIMENT	LOCATION					
	GROUND		SPACE			
			SHUTTLE		SPACE STATION	
	SPONSOR	PANEL	SPONSOR	PANEL	SPONSOR	PANEL
2. CONTROL/STRUCTURES INTERACTION						
STRUCTURAL DYNAMICS						
LARGE SPACE REFLECTORS FLIGHT EXPERIMENTS (DEPLOYMENT, PERFORMANCE, ASSEMBLY)					93,94, 96,97	
ENVIRONMENTAL INFLUENCE ON DYN.					1994	
PASSIVE DAMPING						
ZERO "G" EFFECTS						
CONTROL METHODS						
COFS FLIGHT EXPERIMENT			89,90, 91,92			
FLIGHT DYNAMICS IDENTIFICATION					1992	
DYNAMICS DISTURBANCE CONTROL						
DISTRIBUTED CONTROL EXPERIMENTS						
ADVANCED ADAPTIVE CONTROL					1993	
IN-SPACE ACTIVELY CONTROLLED STRUCTURE			89			
DISTURBANCE CONTROL						
ADAPTIVE CONTROL						
DISTURBANCE REJECTION						

Figure 12(b)

TIME PHASING OF EXPERIMENTS

EXPERIMENT	LOCATION					
	GROUND		SPACE			
			SHUTTLE		SPACE STATION	
	SPONSOR	PANEL	SPONSOR	PANEL	SPONSOR	PANEL
3. SPACE STATION DYNAMIC CHARACTERIZATION						
DYNAMICS OF IOC						
SYSTEM PERFORMANCE TECHNOLOGY					INFINITE SERIES 1992	
ADVANCED CONTROL TECHNOLOGY						

Figure 12(c)

TIME PHASING OF EXPERIMENTS

EXPERIMENT	LOCATION					
	GROUND		SPACE			
			SHUTTLE		SPACE STATION	
	SPONSOR	PANEL	SPONSOR	PANEL	SPONSOR	PANEL
4. SPACE CONSTRUCTION TECHNOLOGY						
DEPLOYABLE						
LARGE SPACE STRUCTURES DEMO.					1992	
ERECTABLE						
ADVANCED ANTENNA ASSEMBLY AND PERFORMANCE					1997	
PRECISION OPTICAL SYSTEM ASSEMBLY					1994	
GROUND/FLIGHT CORRELATION						
EVA LARGE STRUCTURE ASSEMBLY			1988		1993	
SPACE BASED CONSTRUCTION						
LARGE SPACE REFLECTORS					93,94, 96,97	
ON-ORBIT SPACECRAFT ASSEMBLY AND TEST					1993	
SPACE STATION MODIFICATIONS					X	
LDR - SPACE STATION IMPACT					1997	
LDR - SPACE STATION IMPACT					1997	
HYBRID CONSTRUCTIONS						
UTILITIES INTEGRATION						

Figure 12(d)

TIME PHASING OF EXPERIMENTS

EXPERIMENT	LOCATION					
	GROUND		SPACE			
			SHUTTLE		SPACE STATION	
	SPONSOR	PANEL	SPONSOR	PANEL	SPONSOR	PANEL
5. ADVANCED STRUCTURAL CONCEPT						
INFLATABLES					1995	
INFLATABLES RIGIDIZABLE STRUCTURAL ELEMENTS						
JOINING					X	
ION BEAM COLD WELDING						
ELECTRON BEAM WELDING						
FABRICATION					1995	
NEW STRUCTURAL CONCEPTS FACILITY						
ON-ORBIT COMPOSITE FABRICATION						
VAPOR DEPOSITION						
FORM CONSTRUCTION (GEODESIC FORMS)						
SPACE DEBRIS PROTECTION CONCEPTS					1995	
MICRO METERORITE PROTECTION						

Figure 12(e)

COMPONENT TECHNOLOGY

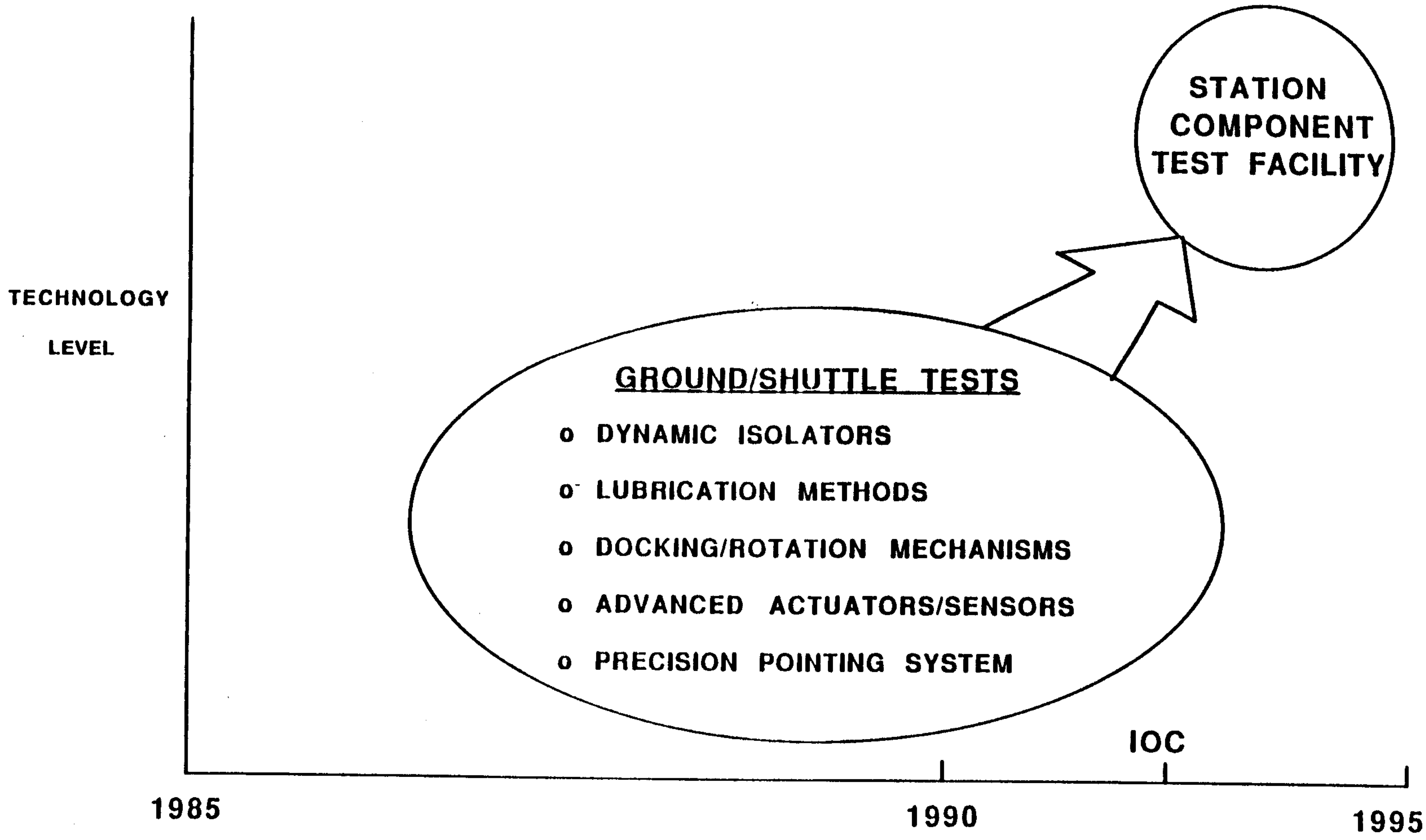
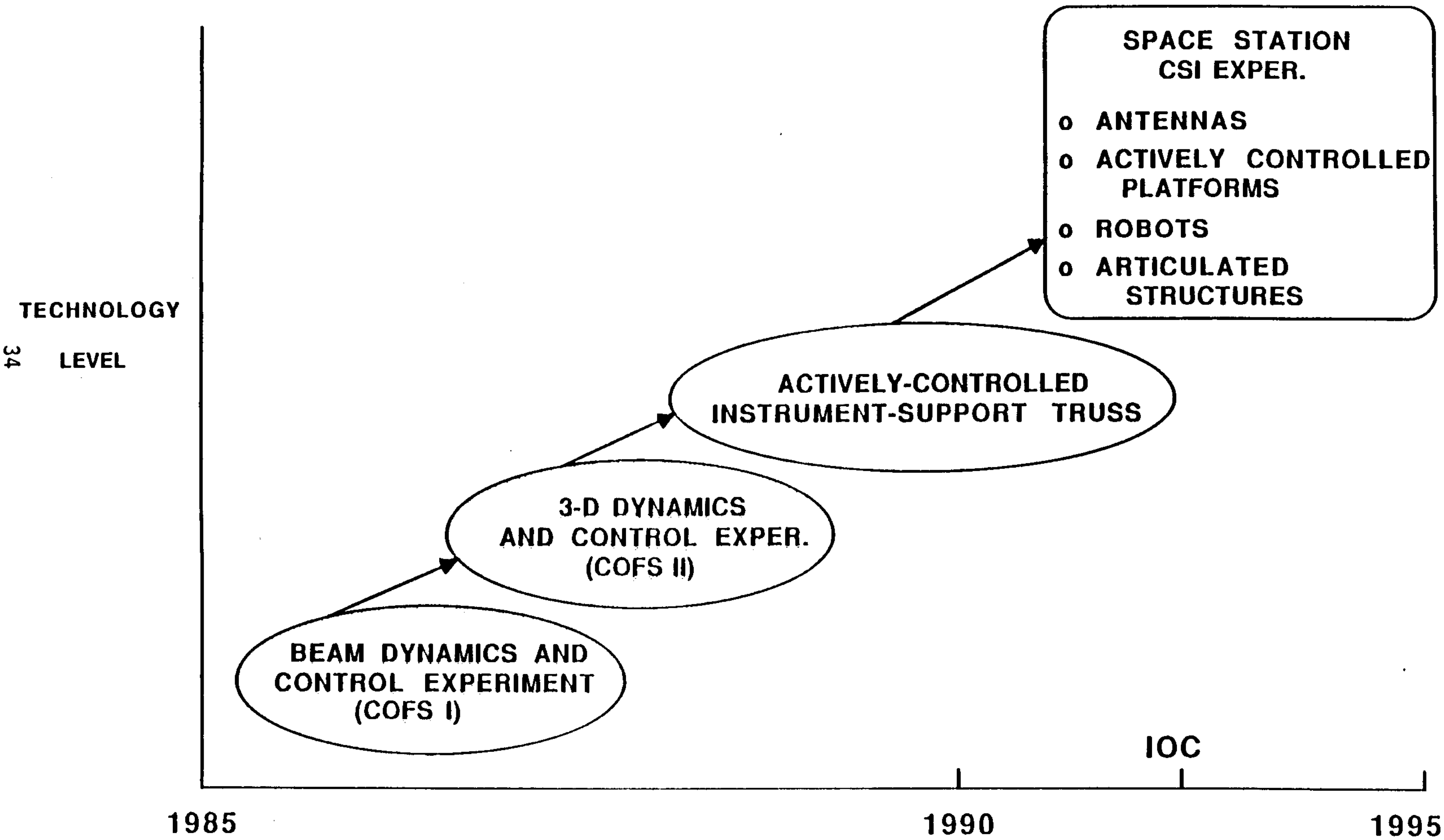
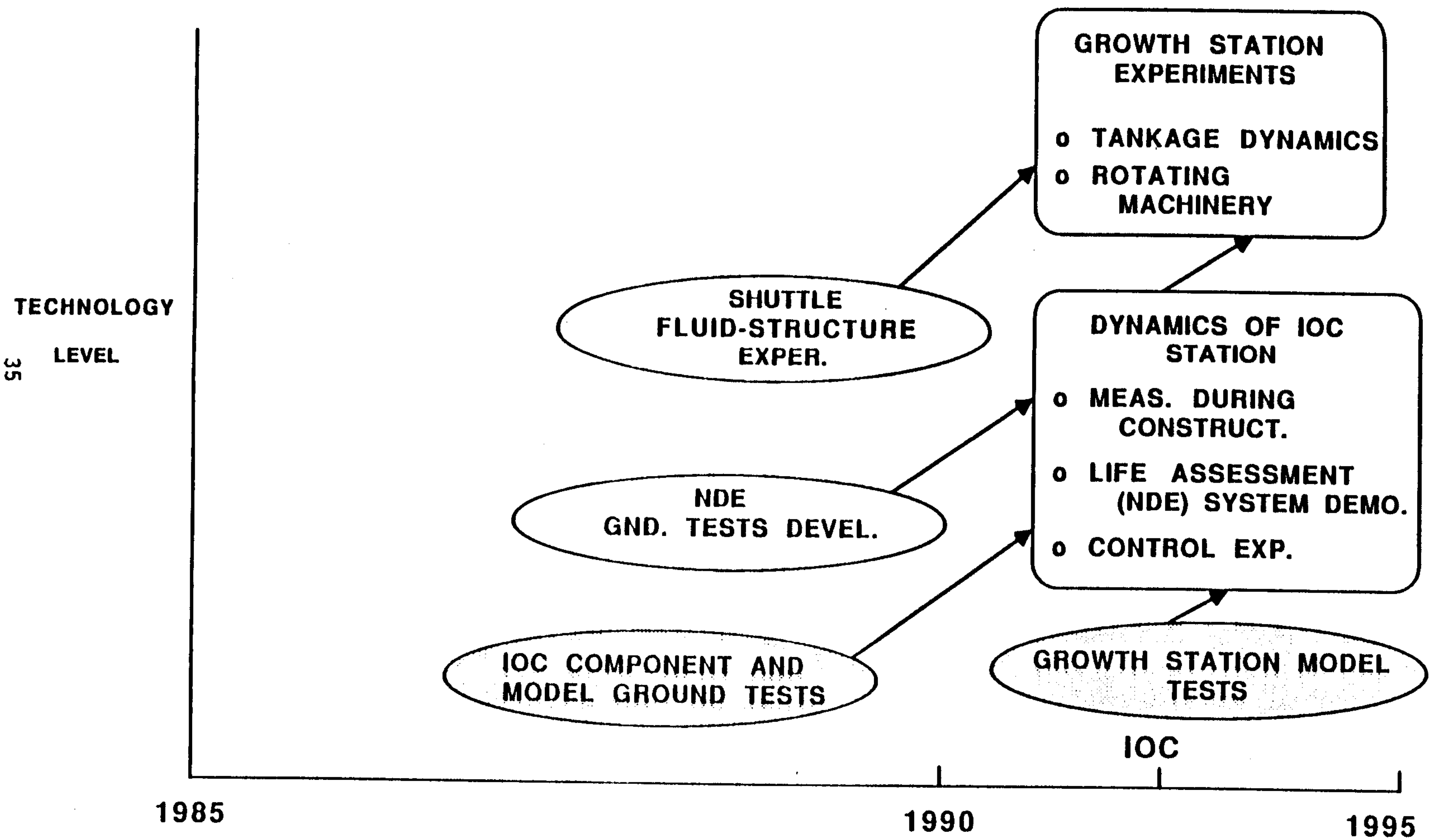


Figure 13

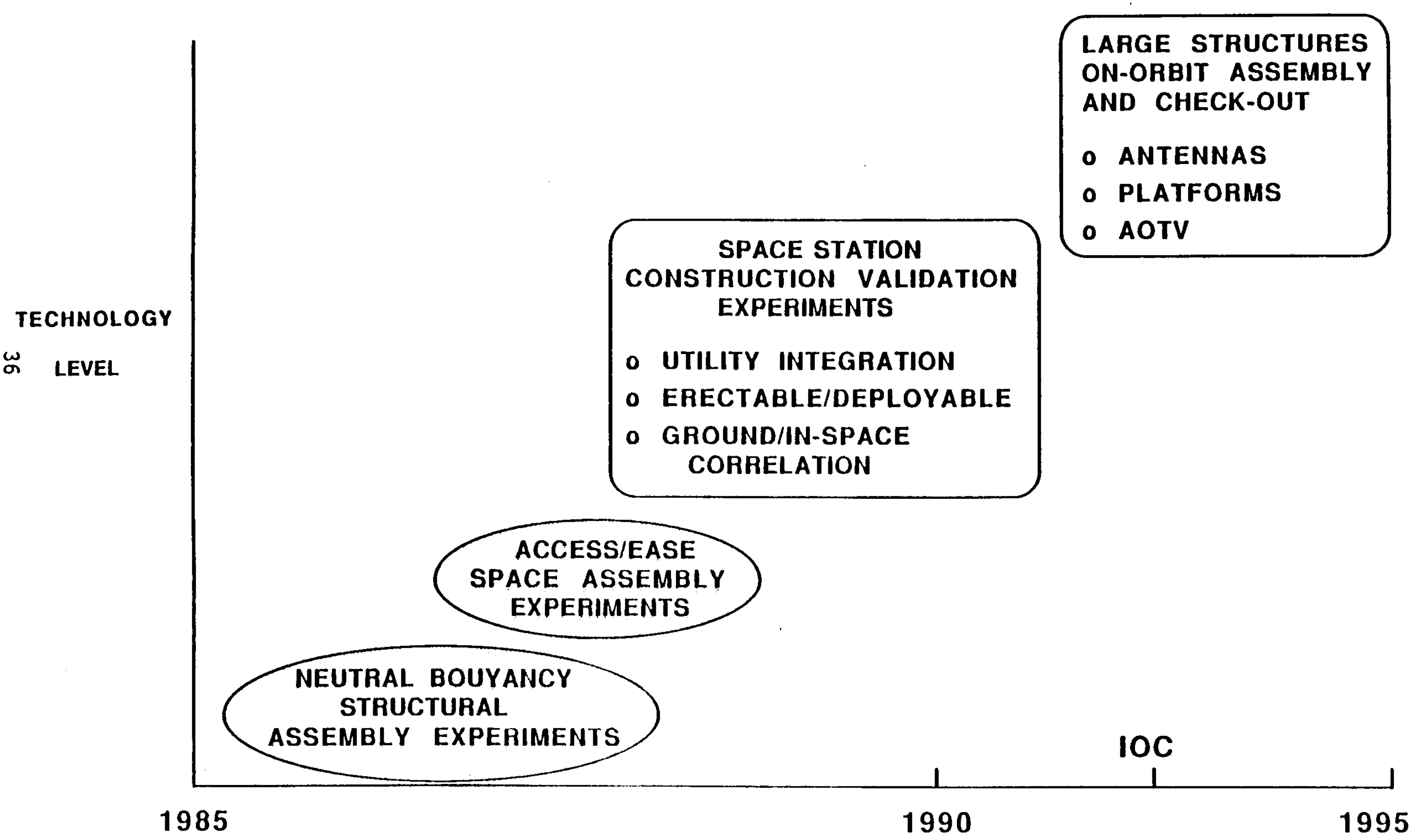
CONTROL/STRUCTURES INTERACTION (CSI)



SPACE STATION DYNAMIC CHARACTERIZATION



SPACE CONSTRUCTION TECHNOLOGY



ADVANCED STRUCTURAL CONCEPTS

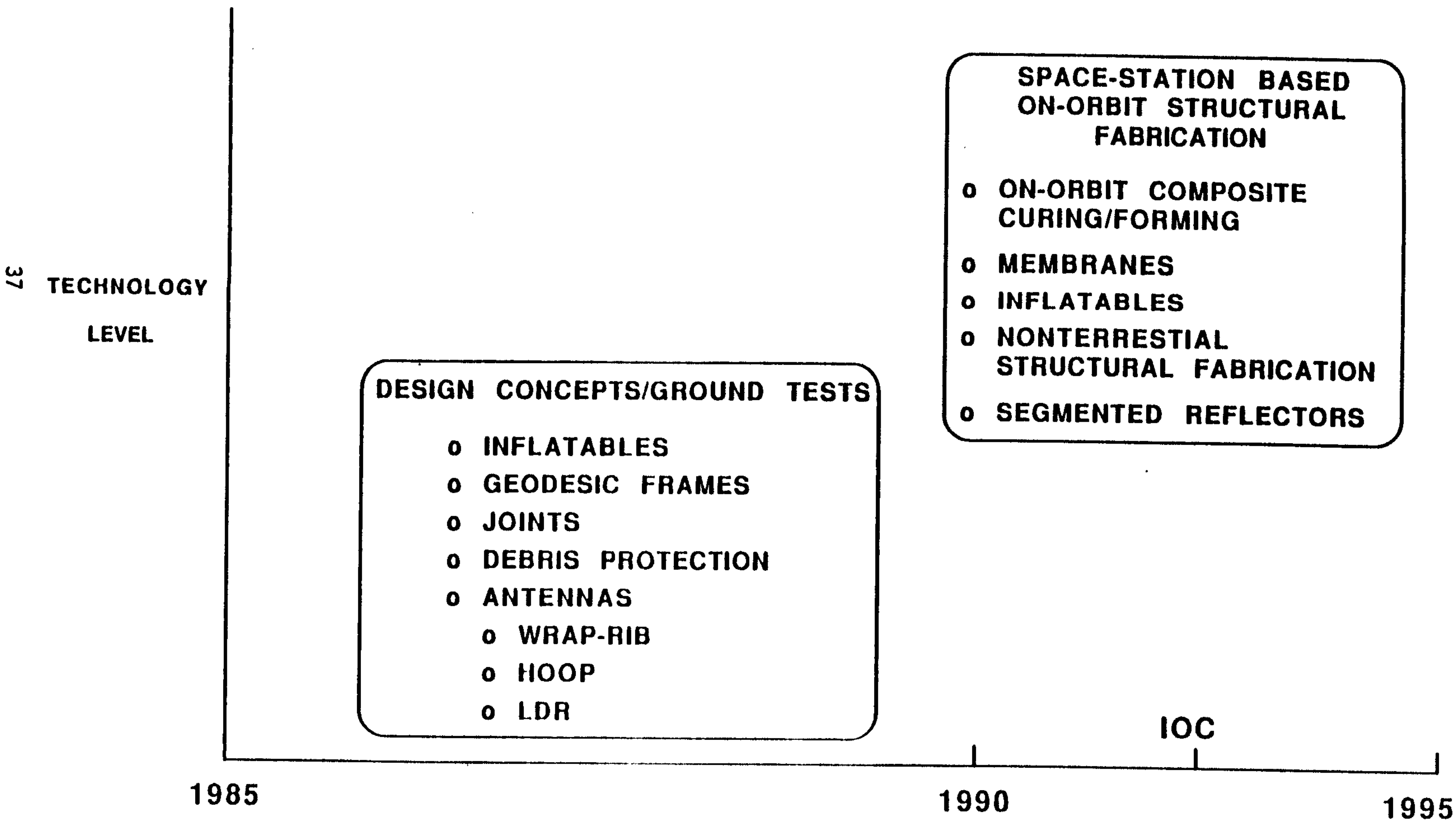


Figure 17

JOINT EFFORT POTENTIALS

ELEMENT	EXAMPLE SOURCE
o ACTUATORS	
- MOMENTUM DEVICES/ENERGY STORAGE	SPERRY, BENDIX, GE, DRAPER, U. OF MD
- PROOF MASS, LDCM	HARRIS
- PIEZOELECTRIC	
- MAGNETIC BEARING ACTUATORS	SPERRY, BENDIX, U. OF MD
- THERMAL	
o SENSORS	
- INERTIAL (STAR, SUN, RATE, GYROS, ETC)	HONEYWELL, BALL AERO., TELEDYNE, BENDIX, MDAC
- THERMISTORS	
- STRAIN	
- ACOUSTIC	
- RENDEZVOUS & DOCKING	
o MIRRORS	PERKIN ELMER, ITEK
o ANTENNA	LOCKHEED, GD, HARRIS, MARTIN
o BEAM, TRUSS	ASTRO, LOCKHEED, GD, MARTIN
o GIMBALS FOR ARTICULATION	SPERRY, BENDIX, GE
o PAYLOAD/EXPERIMENT EQUIPMENT	DELCO, DEC, IBM
o PAYLOAD/EXPERIMENT EQUPMENT	
- PRECISION POINTING	SPERRY, MARTIN
- ISOLATOR	SPERRY, MARTIN
- ERECTABLE TRUSS	MDAC
- DEPLOYABLE BEAM	ROCKWELL

CRITICAL ELEMENTS NEEDED FOR DEVELOPMENT

- o HIGH ACCURACY SURFACE SENSOR (MULTI DOF)
- o REAL-TIME PHOTOGRAMETRIC CONCEPT
- o MID-RANGE MOMENTUM ACTUATORS
- o HIGH SPEED, HIGH CAPACITY FLIGHT COMPUTERS FOR CSI
- o HIGH SPEED, HIGH CAPACITY DATA BASES
- o MULTI-BODY ALIGNMENT TRANSFER & POINTING SYSTEM
- o RELATIVE ALIGNMENT SENSOR
- o VIBRATION ACTUATORS
- o LOW-FREQUENCY ACTUATORS
- o OPTICAL/INERTIAL VIBRATION SENSORS
- o LOW-G ACCELEROMETER
- o LOW-THRUSTER FOR REBOOST

ISSUES: EXPERIMENTAL PROGRAM ORGANIZATION

- A RIGOROUS CRITERION FOR THE SELECTION OF IN-SPACE TECHNOLOGY EXPERIMENTS MUST BE APPLIED

- A FRAME-WORK TO OBJECTIVELY SCREEN EXPERIMENTS MUST BE DEVELOPED

- THE CREATION OF INDUSTRY/NASA/UNIVERSITY TEAMS MUST BE ENCOURAGED TO ACHIEVE CREATIVITY AND COST EFFECTIVENESS

- A SERIOUS EFFORT MUST BE MADE BY NASA TO ALLEVIATE STS AND SPACE STATION INTEGRATION OVERHEAD FOR EXPERIMENTERS

Figure 20

FUTURE COMMUNITY INTERACTION

- o ESTABLISH STRUCTURES, DYNAMICS AND CONTROL EXPERIMENTS REVIEW COMMITTEE
  - QUANTIFY IOC STATION REQUIREMENTS FOR EXPERIMENTS ACCOMMODATION
  - ESTABLISH SPACE EXPERIMENTS SELECTION CRITERIA
  - METHODS TO SIMPLIFY EXPERIMENT INTEGRATION ISSUES
- o NEED FOR FUTURE WORKSHOPS?

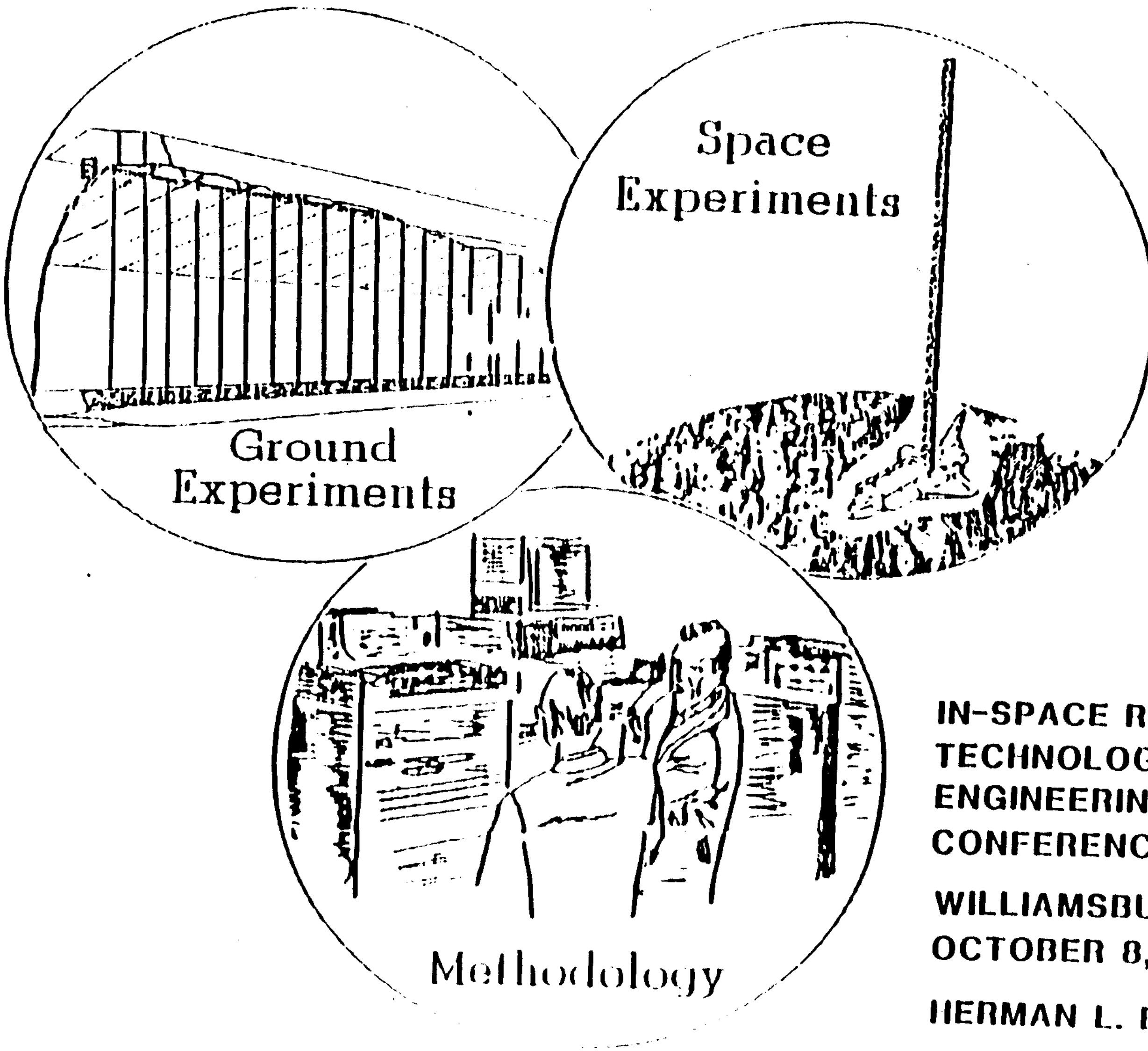
Figure 21

THEME

PRESENTATION

MATERIAL

CONTROL OF FLEXIBLE STRUCTURES



IN-SPACE RESEARCH,
TECHNOLOGY AND
ENGINEERING
CONFERENCE

WILLIAMSBURG, VA.
OCTOBER 8, 1985

HERMAN L. BOHON

CONTROL OF FLEXIBLE STRUCTURES (COFS)

OBJECTIVE

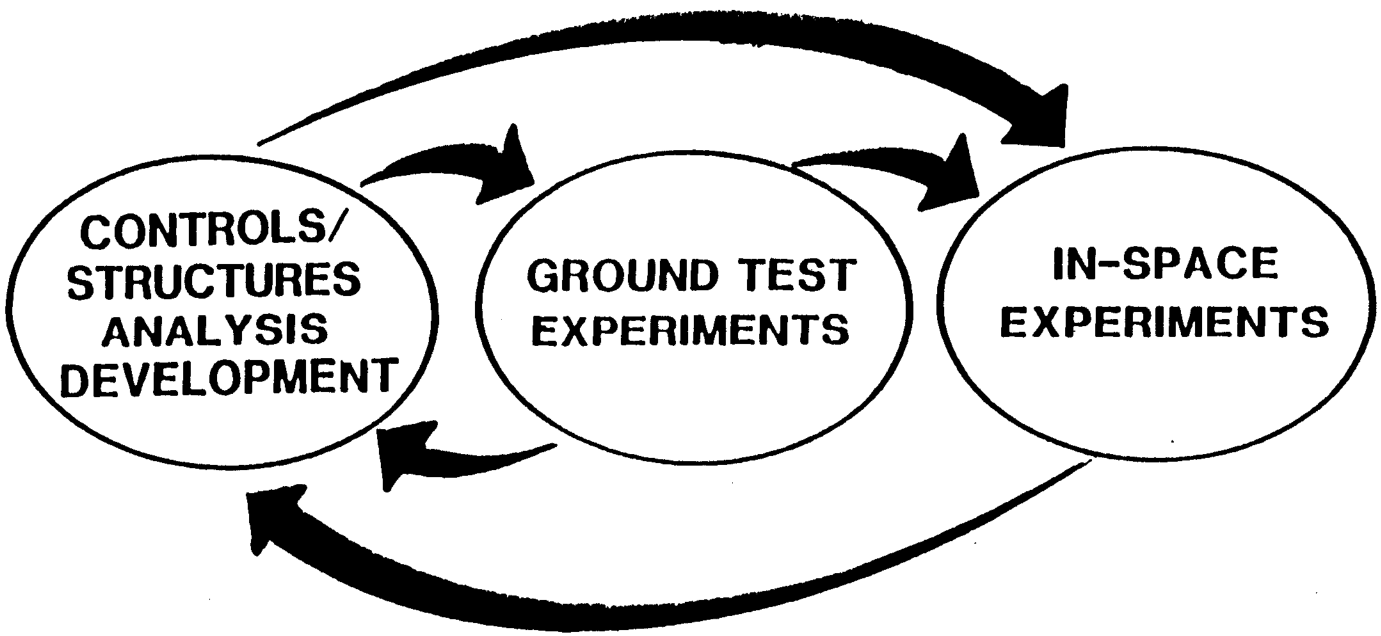
DEVELOP & VALIDATE THE TECHNOLOGY DATA BASE REQUIRED FOR CONFIDENCE IN DESIGN & CONTROL OF LARGE FLEXIBLE SPACECRAFT BY 1992

APPROACH

- DEVELOP & VALIDATE DESIGN & ANALYSIS TOOLS
- DEVELOP & DEMONSTRATE GROUND TEST METHODS
- CONDUCT GENERIC IN-SPACE EXPERIMENTS TO VALIDATE GROUND TEST TECHNOLOGY AND ANALYSIS TOOLS

CONTROL OF FLEXIBLE STRUCTURES

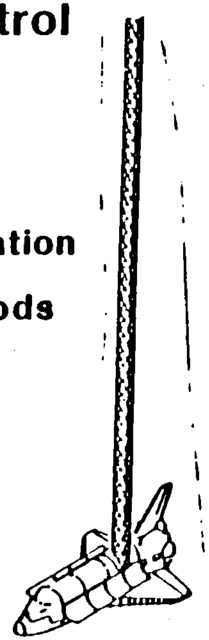
PROGRAM APPROACH



CONTROL OF FLEXIBLE STRUCTURES

COFS I

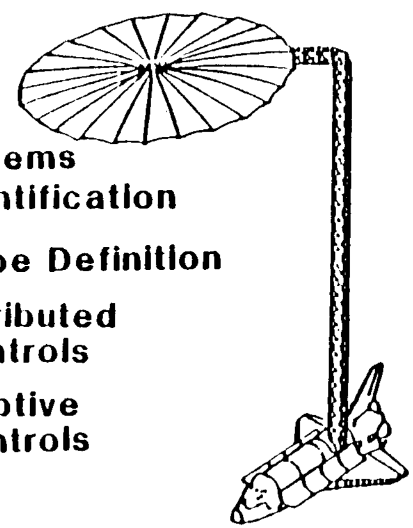
Beam Dynamics & Control



- Systems Identification
- Test Methods
- Distributed Controls

COFS II

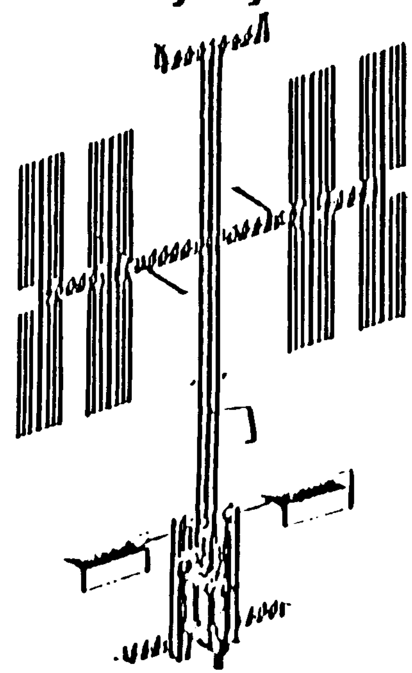
Three-Dimensional Dynamics & Control



- Systems Identification
- Shape Definition
- Distributed Controls
- Adaptive Controls

COFS III

Multi-Body Dynamics

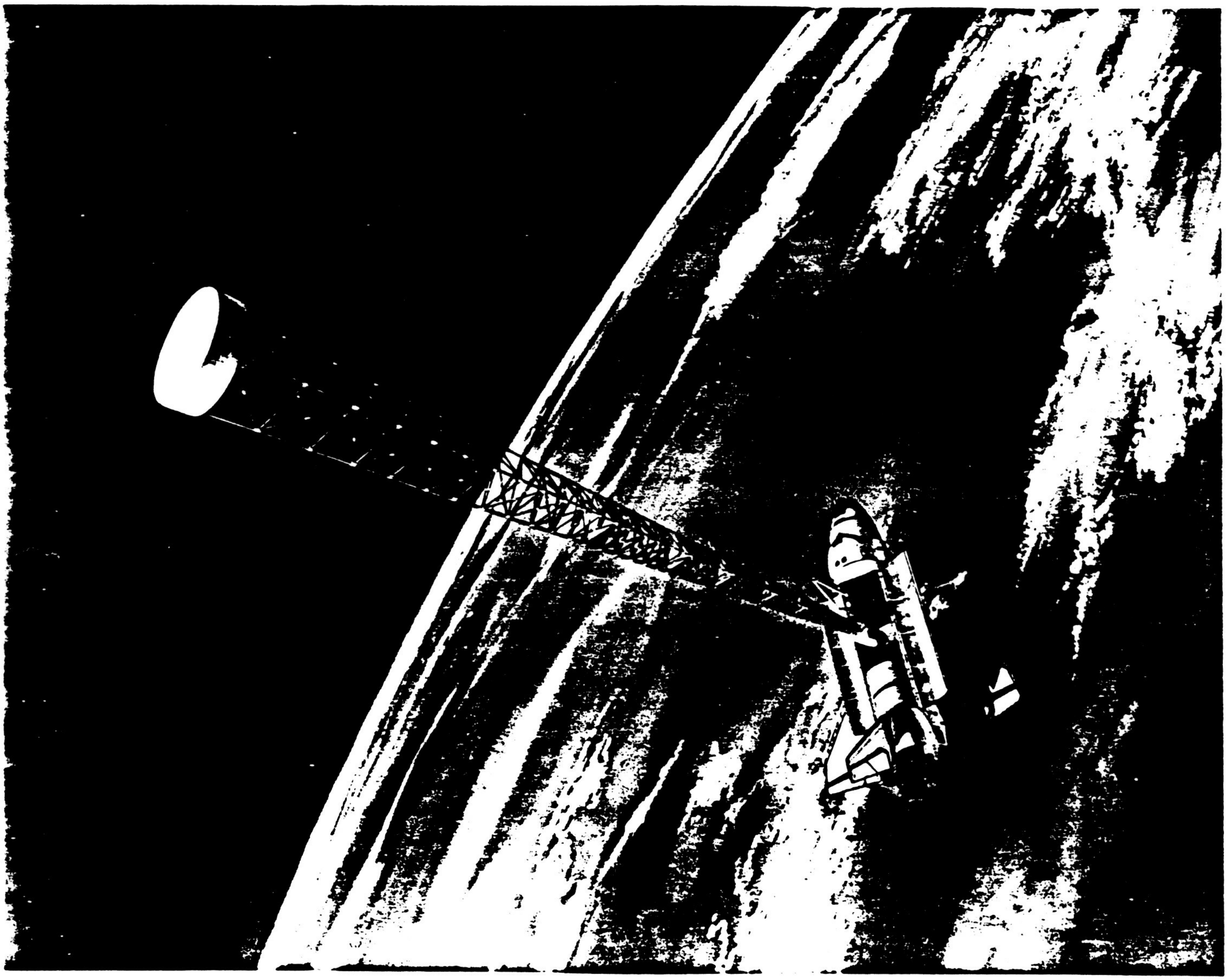


- Test Methods
- Systems Identification
- Model Sensitivities
- Analysis Validation
- Space Station Supporting Technology

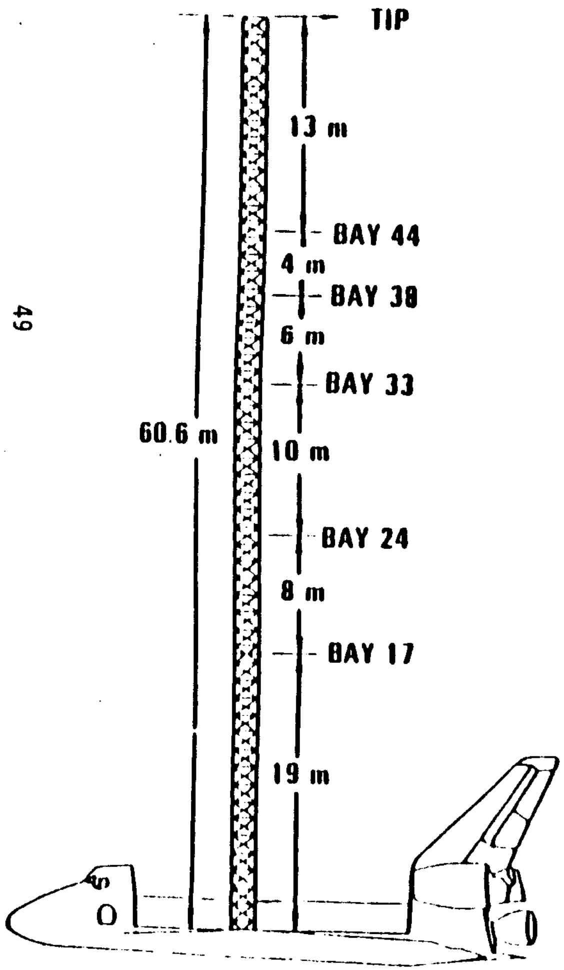
CONTROL OF FLEXIBLE STRUCTURES

COFS I TECHNOLOGY GOALS

- VALIDATE GROUND TEST METHODS
- DEVELOP & VALIDATE IN-SPACE TEST METHODS
- VERIFY CSI ANALYTICAL TOOLS
- ASSESS SCOLING EFFECTS
- EVALUATE DISTRIBUTED CONTROLS METHODS



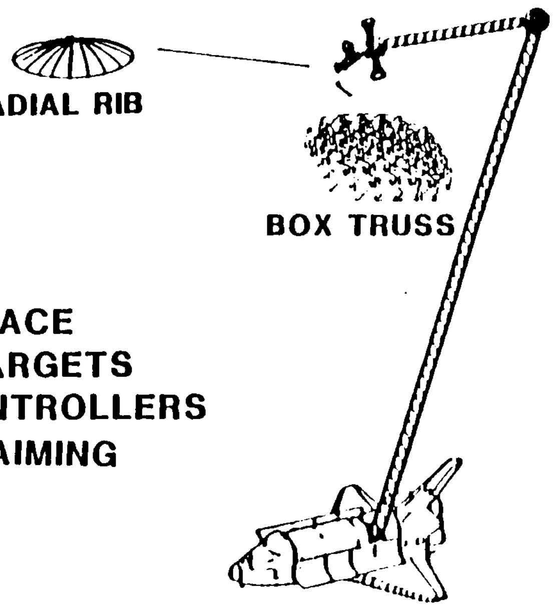
MAST FLIGHT SYSTEM INSTRUMENTATION



	ACTUATOR	GYRO RATE	LINEAR ACCEL.	ANGULAR ACCEL.	STRAIN GUAGE	THERMISTOR	SOURCE TARGET
TIP	4	3	3		6	9	2
BAY 44	2		3	1	6	3	2
BAY 38			2	1	6	3	2
BAY 33	2		3	1	6	3	2
BAY 24			2	1	6	3	2
BAY 17	2		3	1	6	3	2
		3	3		6	3	
	10	6	19	5	42	27	12

CONTROL OF FLEXIBLE STRUCTURES
COFS

COFS II BASELINE CONFIGURATION



BOOM WITH GIMBALS/EXTENSIBLE
LINKS AT EACH END, REACTION
CONTROLS AT TIP FOR MANEUVER
LOAD CONTROL, ACTUATORS,
OPTICAL TARGETS

AREA SURFACE
OPTICAL TARGETS
SHAPE CONTROLLERS
POINTING/AIMING
DEVICES

COFS I MAST
ACTUATORS/SENSORS,
OPTICAL TARGETS

STEP PALLET
REMOTE OPTICAL SENSOR
ROTATIONAL DEVICE
FOR DEPLOYMENT

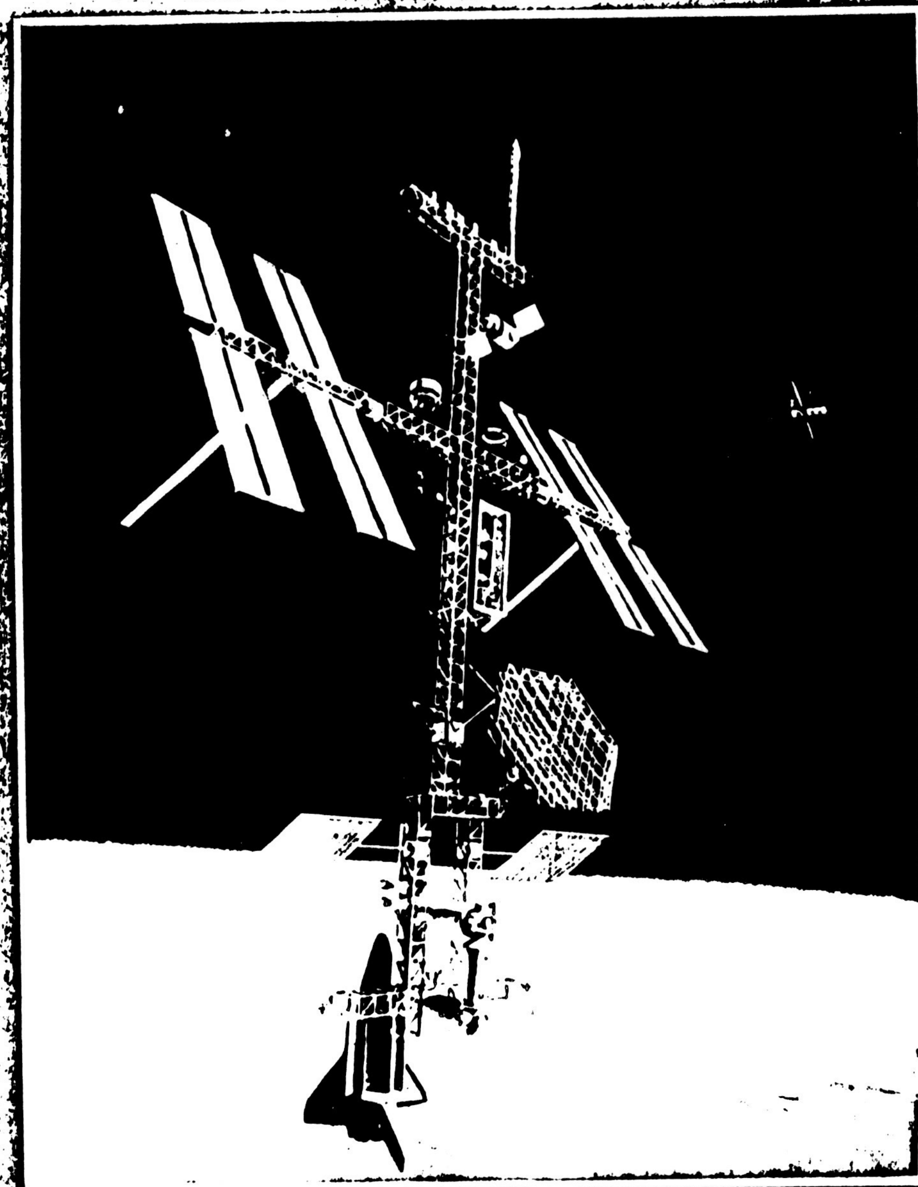
CONTROL OF FLEXIBLE STRUCTURES

COFS II PRIMARY TECHNOLOGY NEEDS

- MANEUVER CONTROL
- ARTICULATION
- POINTING
- SHAPE CONTROL (Quasi-static)
- ALIGNMENT
- SYSTEMS IDENTIFICATION (Modal Complexity)
- DEPLOYMENT DYNAMICS
- ADAPTIVE CONTROLS

CONTROL OF FLEXIBLE STRUCTURES

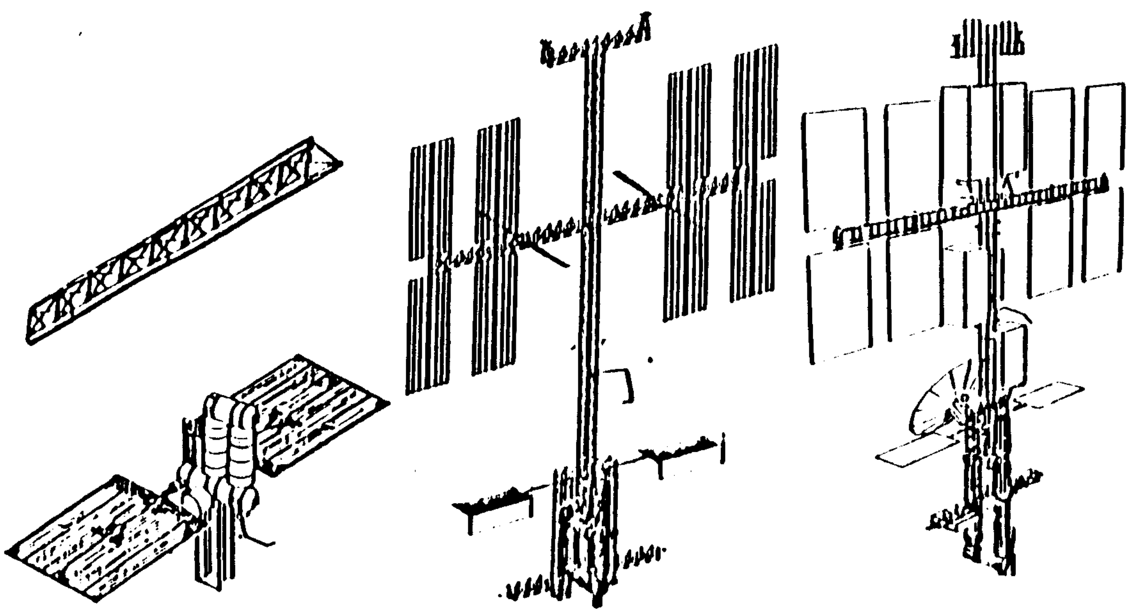
THE MULTI-BODY DYNAMICS CHALLENGE



CONTROL OF FLEXIBLE STRUCTURES

COFS III GROUND TEST PLAN

GROUND TEST HARDWARE



SUBASSEMBLY

MATED MODEL

EVOLVED MODEL

OBJECTIVES

- DETERMINE DYNAMIC CHARACTERISTICS
- VALIDATE CSI ANALYSIS TOOLS
- DETERMINE MODELING SENSITIVITIES
- DEVELOP VIBRATION SUPPRESSION TECHNIQUES
- DEVELOP GROUND TEST METHODS AND CAPABILITY
- SUPPORT SPACE STATION TECHNOLOGY

CONTROL OF FLEXIBLE STRUCTURES

GUEST INVESTIGATOR PROGRAM

OBJECTIVE:

TO PROVIDE OPPORTUNITIES FOR AND PROMOTION OF GENERIC RESEARCH BOTH GROUND AND IN-SPACE AMONG INDUSTRY/ UNIVERSITY AND GOVERNMENT FOR THE DEVELOPMENT OF CONTROLS/STRUCTURES INTERACTION TECHNOLOGY

APPROACH:

ESTABLISH GROUND AND IN-SPACE FACILITIES WHICH PROVIDE FOR INDIVIDUAL AND/OR COMPANY EXPERIMENTS AT MINIMUM COST

PAYOFF:

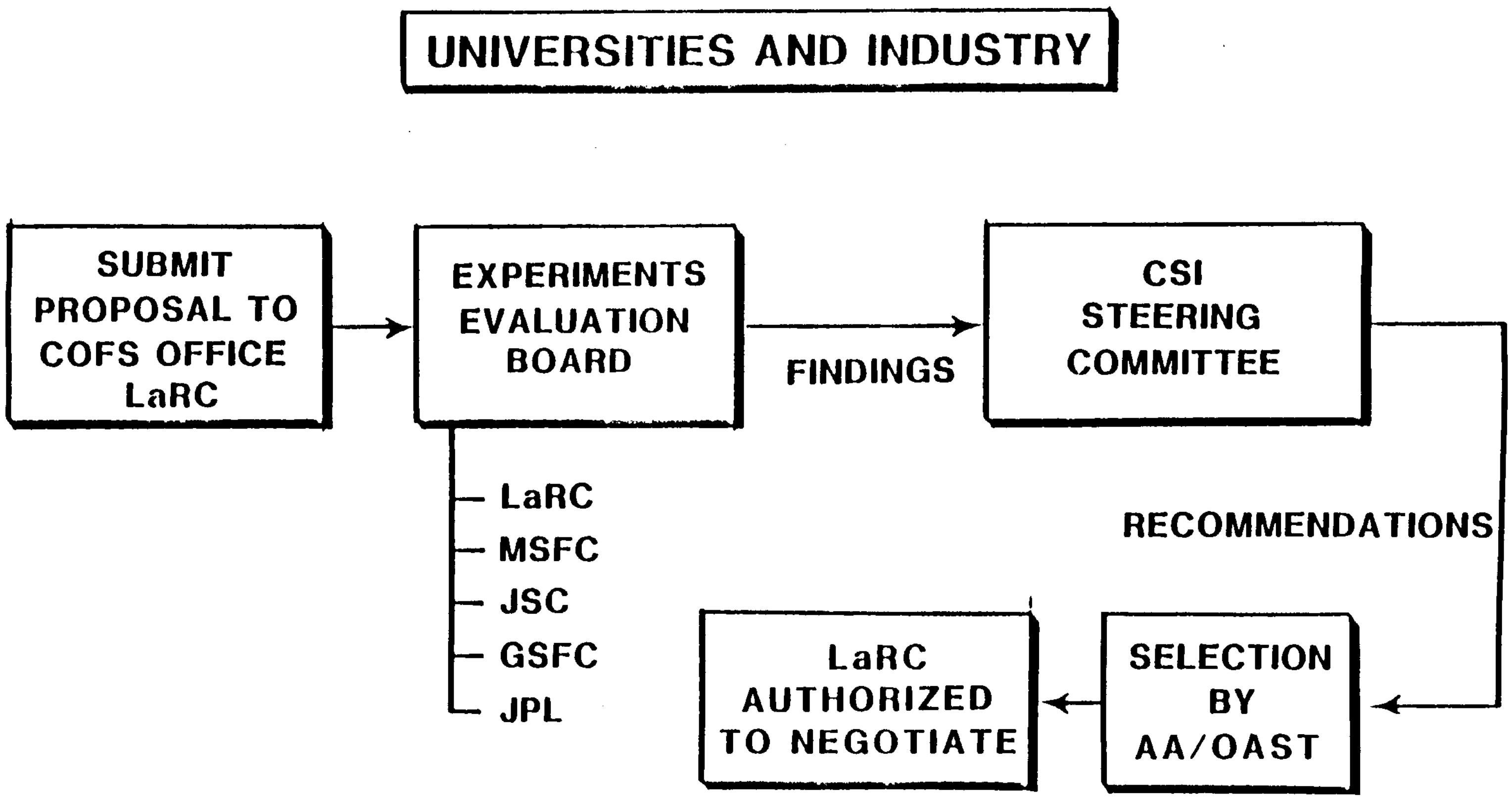
- BROAD BASE FOR ADVANCED CSI METHODOLOGIES
- DISSEMINATION OF PROGRAM DATA & FINDINGS WITHIN CSI COMMUNITY
- IN-SPACE RESEARCH AWARENESS

GUEST INVESTIGATOR OPPORTUNITIES

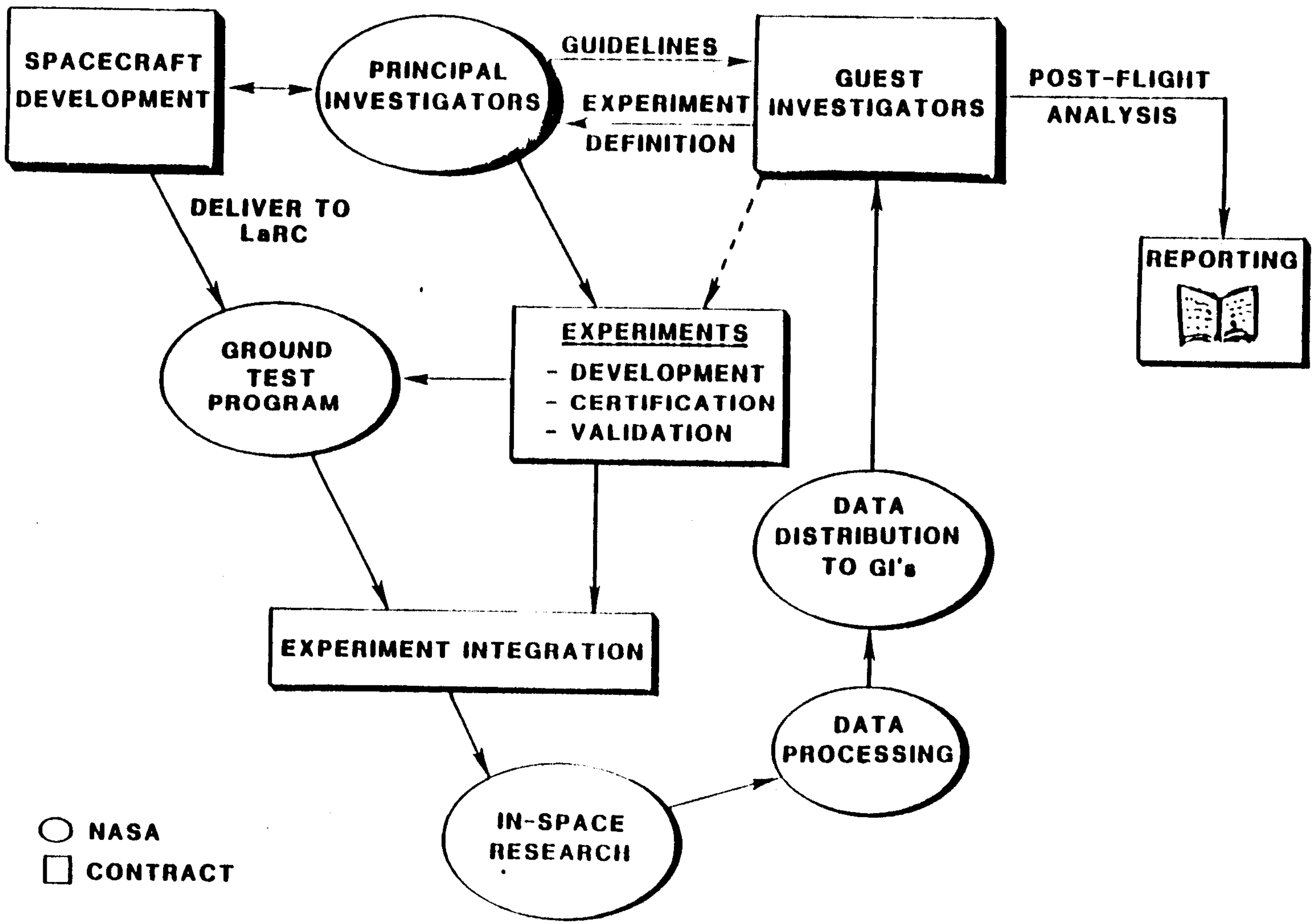
(TYPICAL)

- STRUCTURAL DYNAMICS
- FLEX-BODY CONTROL ALGORITHMS
- SYSTEM IDENTIFICATION ALGORITHMS
- FLIGHT & GROUND TEST METHODS
- MATH MODELLING
- VIBRATION SUPPRESSION
- ANALYSIS OF GROUND & IN-SPACE TEST DATA
- FLIGHT TESTING OF UNIQUE HARDWARE

COFS GUEST INVESTIGATOR SELECTION PROCESS

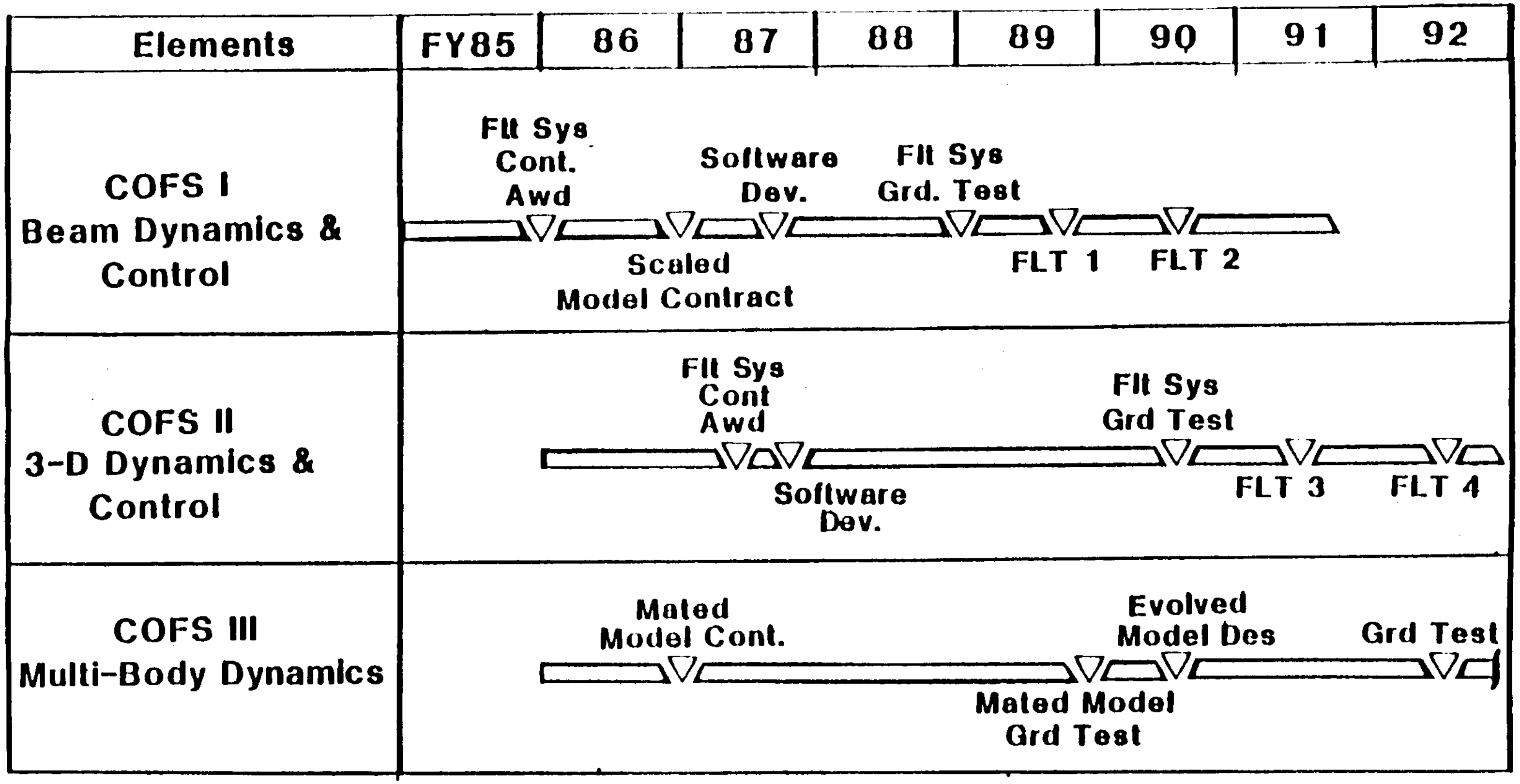


COFS TECHNOLOGY TRANSFER

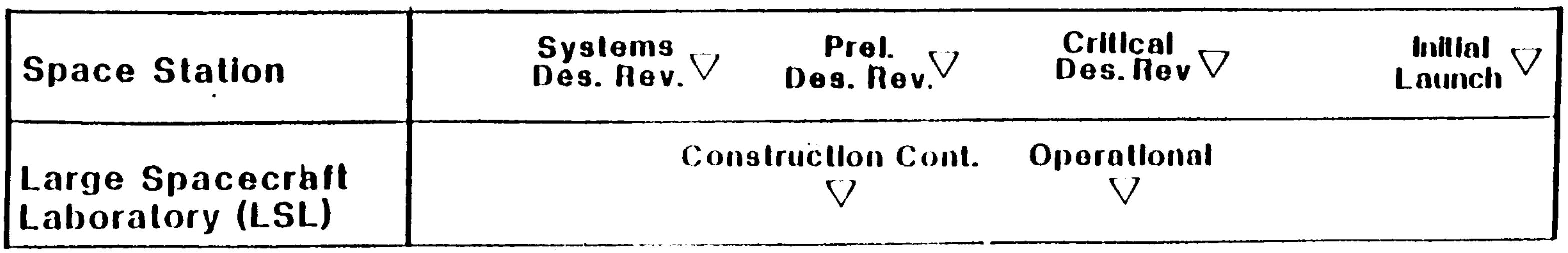


CONTROL OF FLEXIBLE STRUCTURES

SCHEDULE



RELATED PROGRAMS



CONTROL OF FLEXIBLE STRUCTURES

Summary

THE COFS PROGRAM WILL PROVIDE BY 1992:

- TESTED CONTROLS/STRUCTURES INTERACTION ANALYSIS TOOLS
- VALIDATED IN-SPACE CONTROLS TEST METHODS TO SUPPORT FUTURE SPACECRAFT SYSTEMS IDENTIFICATION
- METHODOLOGY TO PREDICT SPACECRAFT PERFORMANCE BY ANALYSIS, LIMITED GROUND TESTS AND IN-SPACE TESTS.

SPACE STATION

SYSTEM PERFORMANCE TECHNOLOGY EXPERIMENT

U. M. Lovelace

SPACE STATION TECHNOLOGY EXPERIMENT

SYSTEM PERFORMANCE TECHNOLOGY EXPERIMENT

OBJECTIVE:

To Employ the IOC Space Station System to Verify and Validate Analytical and Pre-Flight Predictions of System Operational Characteristics.

APPROACH:

A Series of Experiments will be Defined to Collect Data to Compare the As-Built Performance of the Space Station with Predictions Obtained from Analysis and Pre-Launch Tests. All Configurations of the Station will be Modeled and Instrumented to Gather Engineering Data Necessary for the Validation.

SCOPE:

Experiments will Encompass All Phases of the Station Construction and will Continue Past IOC Utilizing the Operational Station as an Experimental Platform.

SPACE STATION
SYSTEM PERFORMANCE TECHNOLOGY EXPERIMENT

Experiment Disciplines

- Structures
- Controls
- Structural Dynamics
- Deployment & Assembly
- Operations

SPACE STATION
SYSTEM PERFORMANCE TECHNOLOGY EXPERIMENT

Experiment Evolution

Identification & Definition
Analysis & Ground Tests
SS Added Requirements

Development & Verification Tests
SS Sensor/Capability Integration
Precursor STS Experiments/Demos

SS Prelaunch Test Data Analysis
Technology Experiments
-- Predictions
-- Execution
-- Analysis

SPACE STATION
SYSTEM PERFORMANCE TECHNOLOGY EXPERIMENT

Near-Term Plans

- Experiment Identification
  - Objectives
  - SS Systems Involved
  - Instrumentation & Unique Equipment
  - Experiment Operation Outline
  - Data & Information Products Outline
- Experiment Definition
  - Integrate & Prioritize
  - Define Development & Implementation Plans

85-93

SPACE STATION
SYSTEMS PERFORMANCE TECHNOLOGY EXPERIMENT

Potential Experiments

(Structures - Structural Dynamics - Deployment & Assembly)

- Damping Mechanisms
- Joining Techniques
- Utility/Component Installation
- Deployment-Erection Components
- Structural Interface Mating
- MRMS Mobility
- Dynamic Characterization
- Component/Module Replacement
- Component Deployment-Assembly
- EVA Repair
- Thermal Mapping-Distortion

SYSTEM PERFORMANCE TECHNOLOGY EXPERIMENT

Candidate

TITLE:

Fundamental Structural Dynamics

EXPERIMENTORS:

Pinson
Brumfield

OBJECTIVE:

Correlate Space Station and Scale Model Ground Test Structural Dynamic Characteristics

INSTRUMENTATION:

Accelerometers
Optical Sensors

85-94

SYSTEM PERFORMANCE TECHNOLOGY EXPERIMENT

Candidate

TITLE:

Structural Integrity Evaluation of Large Redundant Trusswork Systems

EXPERIMENTOR:

Cooper

OBJECTIVE:

Correlate Actual and Predicted Load Distributions through Trusswork for Actual Structure and Selected Simulated Failures

INSTRUMENTATION:

Accelerometers
Strain Gauges

85-95

54-18

FLIGHT DYNAMICS IDENTIFICATION

RAYMOND WOO/DR. NEVILLE MARZWELL

OCTOBER 8-9-10, 1985

IN-SPACE RESEARCH, TECHNOLOGY & ENGINEERING
WORKSHOP

WILLIAMSBURG, VIRGINIA

EXPERIMENT OBJECTIVES:

- TECHNOLOGY
  - DEMONSTRATE AND EVALUATE IN ACTUAL ON-ORBIT ENVIRONMENT
    - SYSTEM IDENTIFICATION METHODOLOGY FOR LFSS
    - SENSOR ARCHITECTURE & TESTING
    - STRUCTURE DYNAMICS PARAMETERS
  - SPACE STATION
    - PROVIDE TECHNOLOGY FOR IDENTIFICATION OF SPACE STATION LARGE FLEXIBLE STRUCTURES.
    - CHARACTERIZED BY SPECIALIZED FACILITIES SUPPORT FOR LARGE SCALE EXPERIMENTATION WITH SPACE STRUCTURES (POWER/THERMAL, COMMUNICATION, DATA PROCESSING, FLEXIBLE PAYLOAD ACCOMMODATIONS/STORAGE, MANPOWER).

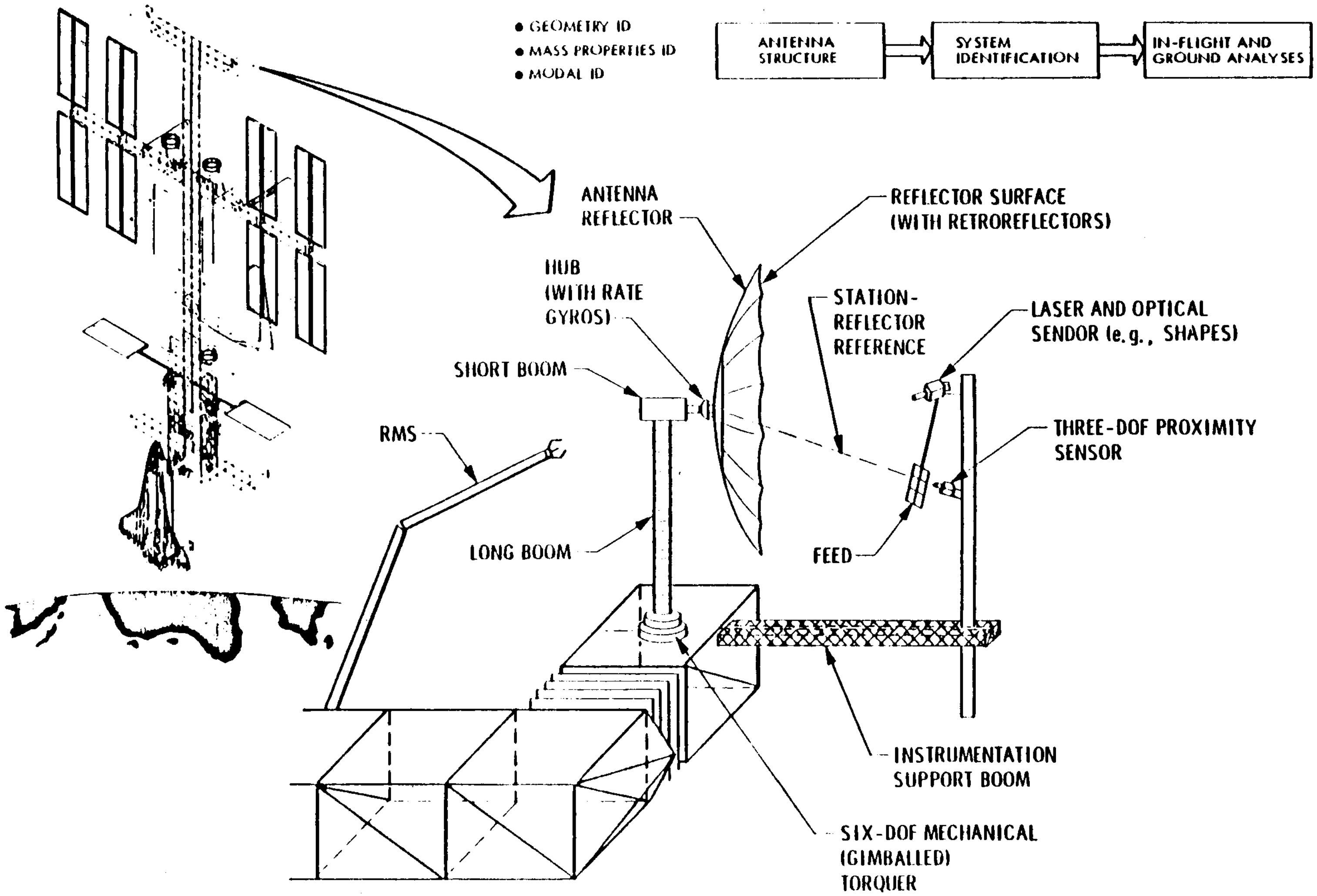
- FLIGHT EXPERIMENT 1: GEOMETRY IDENTIFICATION
  - DEPLOY AN ANTENNA STRUCTURE AS A STRAWMAN TEST ARTICLE FOR EXPERIMENTATION.
  - IDENTIFY USING OPTICAL SENSORS (E.G., JPL SHAPES) THE STATIC AND DYNAMIC SHAPE OF THE ANTENNA REFLECTOR DISH.
  - ESTIMATE THE SHAPE OF THE SURFACE OF THE REFLECTOR VIA A PARABOLIC FIT.

- FLIGHT EXPERIMENT 2: MASS PROPERTIES IDENTIFICATION
  - USE THE ANTENNA STRUCTURE AS IN EXPERIMENT 1.
  - STIMULATE STRUCTURAL MOTION BY COMMANDING LARGE ANGULAR RATES BETWEEN THE ANTENNA REFLECTOR AND THE SUPPORTING BOOMS OF THE STRUCTURE.
  - OBSERVE AND OPTICALLY MEASURE THE STRUCTURAL RESPONSE.
  - GENERATE ESTIMATES OF MASS, CENTER-OF-MASS AND MOMENTS-OF-INERTIA VIA SPECIAL PROCESSING ALGORITHMS FOR PARAMETER IDENTIFICATION.

- FLIGHT EXPERIMENT 3: SYSTEM MODE IDENTIFICATION
  - USE THE ANTENNA STRUCTURE AS IN EXPERIMENTS 2 AND 3.
  - APPLY WIDE-BAND AND NARROW-BAND EXCITATIONS OF THE ANTENNA STRUCTURE BY APPROPRIATELY TORQUING ITS BASE.
  - ESTIMATE THE FOLLOWING STRUCTURAL MODE PARAMETERS WITH SPECIAL PROCESSING ALGORITHMS VIA OPTICAL MEASUREMENTS OF STRUCTURAL RESPONSE
    (A) MODAL FREQUENCIES
    (B) DAMPING RATIOS
    (C) MODE SHAPES

JPL

TDMX 2071 FLIGHT DYNAMICS IDENTIFICATION
(VOLUME 8)



ACCOMMODATION REQUIREMENTS

EXPERIMENT TITLE: TDMX 2071 - FLIGHT DYNAMICS IDENTIFICATION

PRINCIPAL INVSTIGATOR(S): RAYMOND WOO/DR. NEVILLE MARZWELL

ADDRESS: BUILDING 198 ROOM 326

PROPOSED FLIGHT DATE 1992 YEAR(S)

OPERATIONAL DAYS REQUIRED 90 (PER YEAR)

MASS 265 KG

VOLUME: 19 M^3

STORED W 3. x L 2.11 x H 3. = 19. M3

DEPLOYED W 15. x L 15. x H 20. = 4500. M3

INTERNALLY ATTACHED NO (YES/NO)
EXTERNALLY ATTACHED YES (YES/NO)
FORMATION FLYING NO (YES/NO)

ORIENTATION (inertial, solar, earth, other) ____

EXTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days.	Interval
SET-UP:	18	1	
OPERATIONS:			
SERVICING:	9	2	30

INTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days.	Interval
SET-UP:	5	1	
OPERATIONS:	5	15	30
SERVICING:	10	1	30

POWER REQUIRED:

0.700 KW AC & DC ~~AC or DC~~ (circle one)

5 Hrs/Day 90 No. of days

DATA RATE: .05 Megabits/second

DATA STORAGE: .142 Gigabits

S5-18

ADVANCED CONTROLS

TDM - 2414

CLAUDE R. KECKLER
NASA LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA

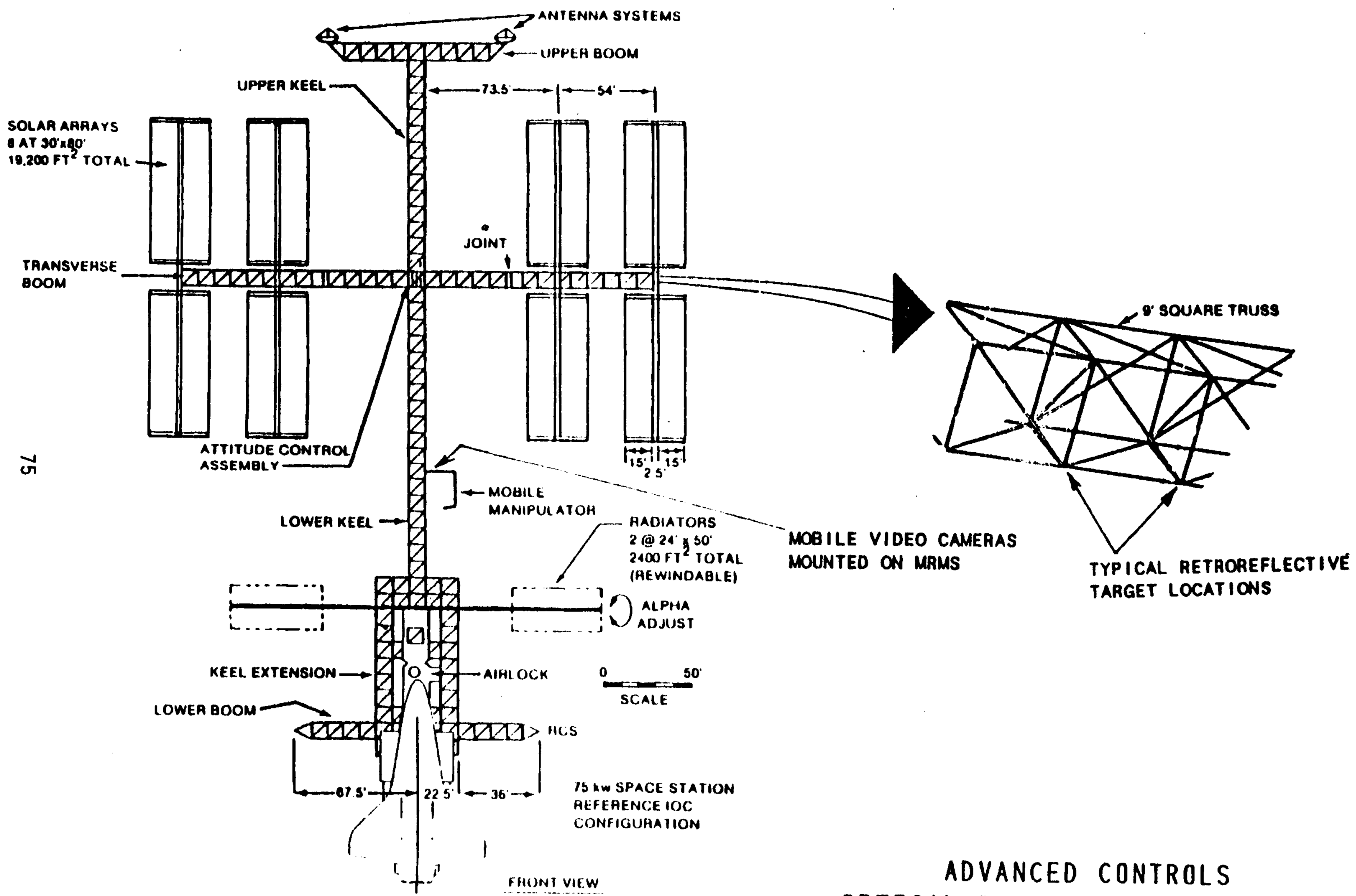
NASA - RT&E WORKSHOP
WILLIAMSBURG, VIRGINIA
OCTOBER 8-10, 1985

EXPERIMENT OBJECTIVE

The goal of this technology demonstration mission is to develop and validate the enabling technology for the modeling, identification, and control of large, complex, flexible spacecraft. The specific objectives attendant to this goal are to examine the applicability of distributed parameter modeling of large, complex spacecraft which cannot be adequately tested on the ground; evaluate system identification techniques and algorithms for such large structures; determine the structural dynamics characteristics of this large vehicle; and quantify the damping of joints in a zero-g environment. In addition, techniques for vibration suppression, figure control, and fine pointing shall also be evaluated. The robustness of control system designs shall also be examined for an evolving and changeable configuration such as associated with the Space Station. The integration and viability of on-line system identification shall also be characterized.

EXPERIMENT DESCRIPTION

A hardware complement for this experiment shall consist of rate sensors, accelerometers, momentum control actuators, etc. and will be located on the station mobile remote manipulator system (MRMS). The MRMS, or a duplicate thereof, will be moved to various locations along the Space Station structure and clamped down at various hard points on the structure. At these locations, experiment sequences will be performed to evaluate the viability of the various techniques and algorithms as the structure's characteristics, as seen by the experiment, are altered. Various identification algorithms and concepts will be evaluated. The outputs from these will be used for structural validation, input to control approaches and designs, and definition of hierarchical control concepts. Fault and configuration tolerant control techniques will be examined and distributed control approaches investigated. Crew involvement for these tasks is expected to consist of installation and checkout of the hardware complement, experiment sequencing, and occasional monitoring of experiment operation. It is recommended that this operation be conducted immediately after IOC start, and is expected to require and operation period of 1 year.



ADVANCED CONTROLS
OPTICAL REMOTE SENSING CONCEPT

EXPERIMENT TITLE: Advanced Controls

PROPOSED FLIGHT DATE - 1992 YEAR

OPERATIONAL DAYS REQUIRED - 365

MASS - 300 KG

VOLUME:

	W	x L	x H	=	
STORED				0.5	M^3
DEPLOYED				0.5	M^3

INTERNALLY ATTACHED ______ (YES/NO)
EXTERNALLY ATTACHED Yes (YES/NO)
FORMATION FLYING ______ (YES/NO)

ORIENTATION (inertial, solar, earth, other) Any

EXTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days	Interval
SET-UP:	6	6	
OPERATIONS:			
SERVICING			

INTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days	Interval
SET-UP:			
OPERATIONS:	2	100	3 days
SERVICING			

POWER REQUIRED:

1 KW AC or DC (circle one)

24 Hrs/Day 365 No. of days

DATA RATE: 0.1 Megabits/second

DATA STORAGE: 0.05 Gigabits

S6-18

ADVANCED EXPERIMENT POINTING AND ISOLATION DEVICE

TDM - 2432

CLAUDE R. KECKLER
NASA LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA

NASA - RT&E WORKSHOP
WILLIAMSBURG, VIRGINIA
OCTOBER 8-10, 1985

Advanced Experiment Pointing and
Isolation Device - C. R. Keckler

EXPERIMENT OBJECTIVE

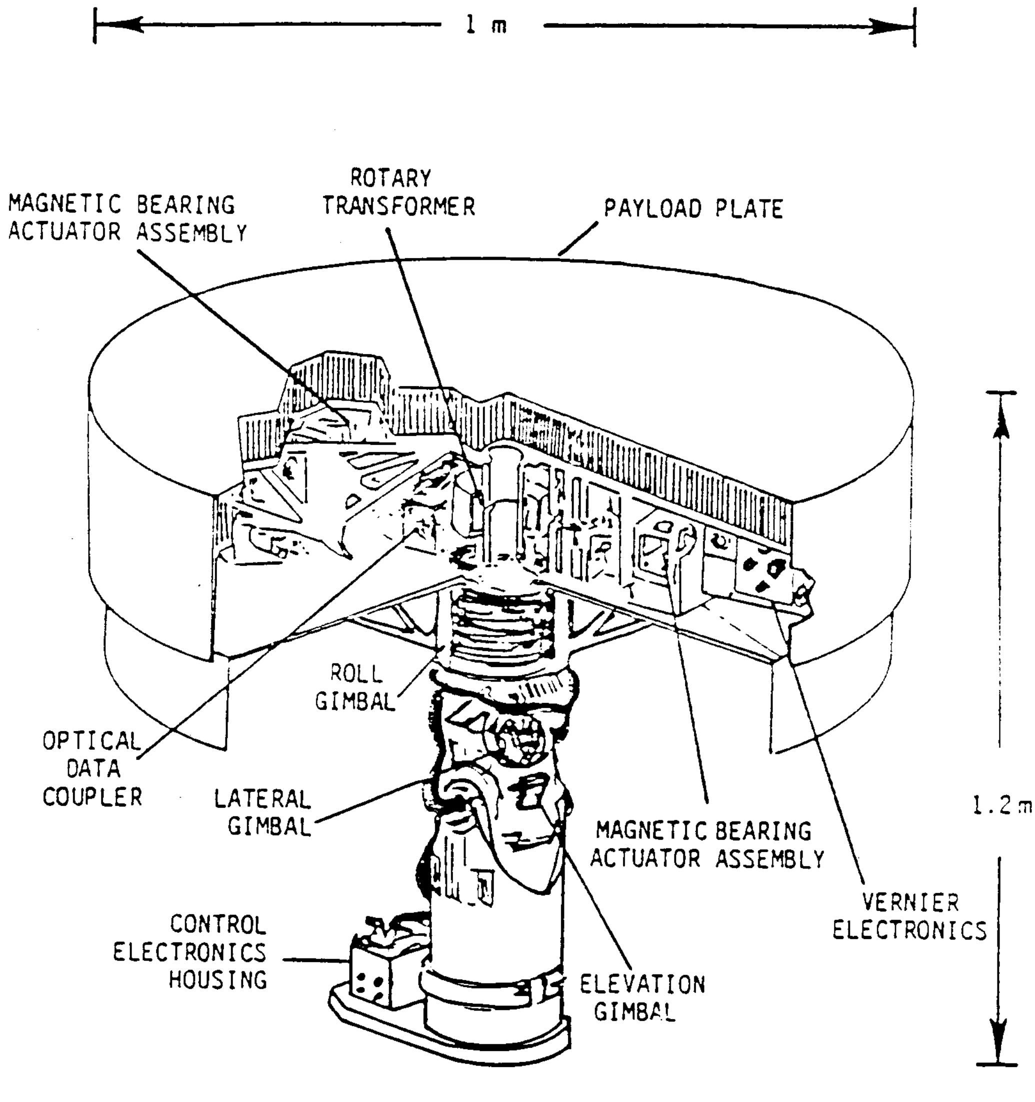
The goal of this experiment is to establish the technology required to satisfy the objectives of missions demanding highly accurate and stable pointing or micro-gravity environments. The specific objectives attendant to this goal are to provide subarcsecond (~0.01 sec) pointing and long term stabilization for experiments dedicated to stellar, solar, and terrestrial observations in the presence of disturbances attendant to manned orbital vehicles. In addition, this experiment will demonstrate the capability of this system concept in providing the micro-gravity environment required by acceleration sensitive processes and developments such as electrophoresis, crystalography, and pharmaceutical operations.

EXPERIMENT DESCRIPTION

The experiment to be conducted in this technology demonstration and validation will utilize the hardware concept developed for the Annular Suspension and Pointing System (ASPS). The hardware will be delivered to orbit and installed on the Space Station. Pointing and stability tests will be conducted in the normal Space Station operational environment. The sensor package required to conduct this evaluation will consist of an inertial reference unit, a complement of accelerometers, and an inertial position sensor commensurate with the ongoing mission profiles. Should it prove advantageous from a manifest and accommodations standpoint, an operational payload may be carried by the pointing system during this validation period, in which case the position sensor will be selected to satisfy this payload's requirements. Following the pointing and stability tests, algorithm and sensor complement changes will be effected from the operational console and vibration isolation tests conducted. These test will be conducted under known disturbance profiles provided by an integral disturbance generator, as well as from scheduled and random Space Station disturbances. Crew involvement for this experiment scenario shall consist of experiment integration and checkout, sequencing, and occasional monitoring. It is postulated that this experiment should be conducted as soon as possible after IOC start because of its long term applications and benefits potential. It is estimated that a period of thirty days will be sufficient to achieve all experiment objectives.

TDMX 2432 - ADVANCED EXPERIMENT POINTING AND ISOLATION DEVICES

Experimenter: C. R. Keckler



Annular Suspension and Pointing System Concept

EXPERIMENT TITLE: Advanced Experiment Pointing and Isolation Device

PROPOSED FLIGHT DATE - 1992 **YEAR**

OPERATIONAL DAYS REQUIRED - 30

MASS - 1421 **KG**

VOLUME:

	W		L		H		=	
STORED	1.0	x	1.535	x	______	=	0.31	M^3
DEPLOYED	1.0	x	1.535	x	______	=	0.31	M^3

INTERNALLY ATTACHED ______ **(YES/NO)**
EXTERNALLY ATTACHED Yes **(YES/NO)**
FORMATION FLYING ______ **(YES/NO)**

ORIENTATION (inertial, solar, earth, other) Any

EXTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days	Interval
SET-UP:	4	1	
OPERATIONS:			
SERVICING			

INTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days	Interval
SET-UP:	5	1	
OPERATIONS:			
SERVICING			

POWER REQUIRED:

0.296 **KW** **AC or DC (circle one)**

24 **Hrs/Day** 30 **No. of days**

DATA RATE: 0.06 **Megabits/second**

DATA STORAGE: 0.2 **Gigabits**

S9-18

LARGE SPACE STRUCTURES DISTURBANCE SUPPRESSION

SPACE STATION TECHNOLOGY FLIGHT EXPERIMENT

RAYMOND WOO/DR. NEVILLE MARZWELL

OCTOBER 8-9-10, 1985

IN-SPACE RESEARCH, TECHNOLOGY & ENGINEERING WORKSHOP

WILLIAMSBURG, VIRGINIA

EXPERIMENT OBJECTIVES

O TECHNOLOGY
- DEMONSTRATE AND EVALUATE DYNAMIC DISTURBANCE SUPPRESSION/REJECTION TECHNOLOGY/TECHNIQUES DEVELOPED FOR LFSS.
- ASSESS AND VALIDATE VIBRATION ISOLATION METHODOLOGY, DISTURBANCE CONTROL SOFTWARE/HARDWARE, SENSORS/ACTUATORS.
- EVALUATE SYSTEM DESIGN AND TRADE-OFFS FOR DISTURBANCE SUPPRESSION APPLICATIONS

- SPACE STATION
  - O PROVIDE TECHNOLOGY FOR LARGE SPACE STRUCTURES DISTURBANCE SUPPRESSION/REJECTION/ISOLATION
  - O CHARACTERIZE SPECIALIZED FACILITIES SUPPORT FOR LARGE SCALE EXPERIMENTATION WITH SPACE STRUCTURES (POWER/THERMAL, COMMUNICATION, DATA PROCESSING, FLEXIBLE PAYLOAD ACCOMMODATIONS/STORAGE, MANPOWER)

- FLIGHT EXPERIMENT 1: BASIC SLEW DEMONSTRATION
  - DEPLOY AN ANTENNA STRUCTURE AS A STRAWMAN TEST ARTICLE FOR EXPERIMENTATION.
  - EXCITE OR STIMULATE STRUCTURAL MODES THROUGH A SERIES OF CONTROLLED SLEW MANEUVERS USING DIFFERENT COMMAND GENERATORS.
  - MEASURE AND COMPARE ANTENNA JITTER INDUCED BY THE DIFFERENT COMMAND GENERATORS AND VERIFY ANALYTICAL PREDICTION OF SUCH JITTER.
  - INVESTIGATE COMMAND TECHNIQUES FOR MANEUVERING THE ANTENNA STRUCTURE SO AS TO MINIMIZE FLEXIBLE BODY VIBRATIONS.

- FLEXIBLE EXPERIMENT 2: CLOSED-LOOP CONTROLLED DEMONSTRATION
  - VERY SIMILAR TO THAT IN EXPERIMENT 1, EXCEPT THAT SLEWING IS PERFORMED IN THE PRESENCE OF CONTROL ACTUATION GOVERNED BY DISTRIBUTED CONTROL LAWS/ALGORITHMS.
  - MEASURE AND COMPARE ANTENNA JITTER INDUCED BY THE DIFFERENT COMMAND GENERATORS IN THE PRESENCE OF CLOSED-LOOP DISTRIBUTED CONTROL ACTUATION.
  - COMPARE EXPERIMENT OUTCOME, PARTICULAR DISTURBANCE LEVELS/JITTER, TO THE RESULTS OBTAINED IN EXPERIMENT 1. TO ASSESS AND EVALUATE THE EFFECTIVENESS OF DISTRIBUTED FEEDBACK CONTROL IN THE PRESENCE OF STRONG DISTURBANCES AND EXCITATIONS THAT ARE INPUT TO THE STRUCTURAL SYSTEM.

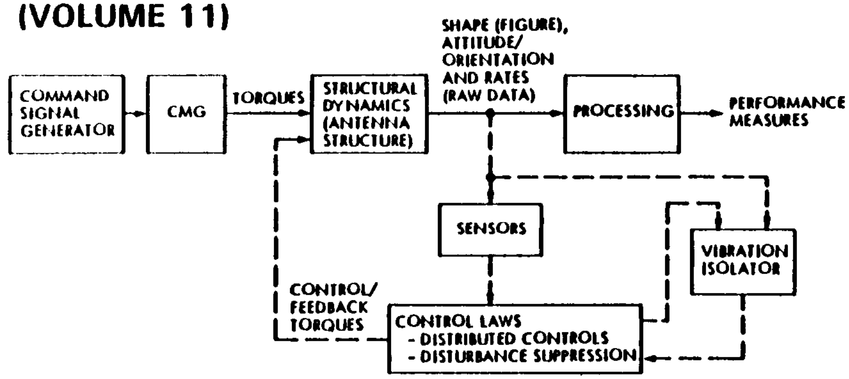
- FLIGHT EXPERIMENT 3: DISTURBANCE CONTROL DEMONSTRATION

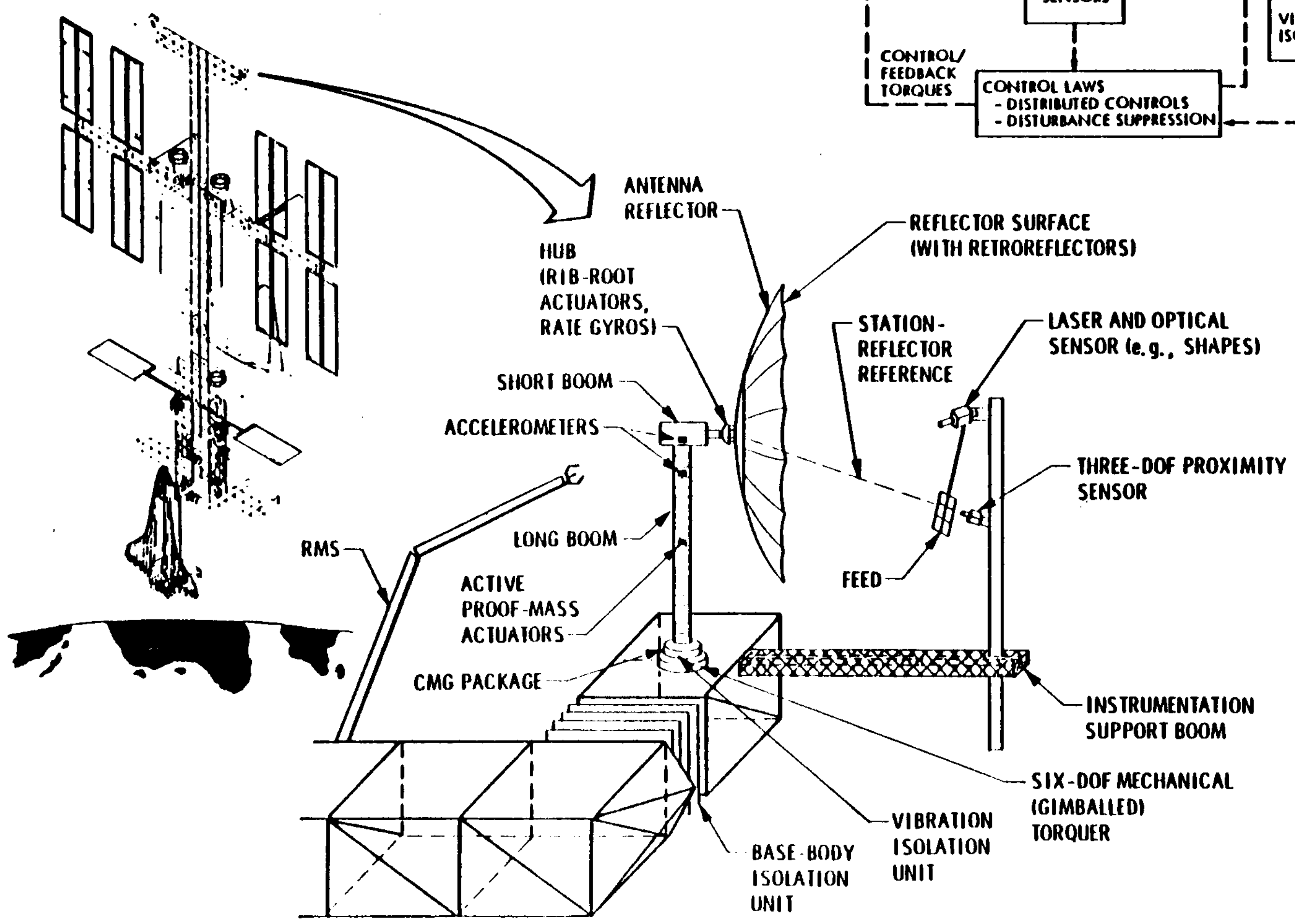
  - SIMILAR TO THAT IN EXPERIMENT 2, EXCEPT THAT DISTURBANCE CONTROL SOFTWARE MODULE AND VIBRATION ISOLATION EQUIPMENT ARE INCORPORATED AS PART OF THE CLOSED-LOOP CONTROL SYSTEM BEING DEMONSTRATED.
  - THE FIRST PHASE CONSISTS OF EXPERIMENTATION WITH THE DISTURBANCE CONTROL SOFTWARE MODULE ONLY, I.E. WITHOUT VIBRATION ISOLATION HARDWARE.
  - THE SECOND PHASE CONSISTS OF THE ADDITION OF VIBRATION ISOLATION HARDWARE TO ENHANCE DISTURBANCE REJECTION AND VIBRATION SUPPRESSION.
  - ANTENNA JITTER WILL AS IN PRECEDING EXPERIMENTS BE MEASURED AND COMPARISONS MADE BETWEEN DIFFERENT COMMAND GENERATORS.
  - EXPERIMENT OUTCOME WILL BE COMPARED TO THOSE OBTAINED IN EXPERIMENT 1 AND 2 TO ASSESS AND EVALUATE THE EFFECTIVENESS AND UTILITY OF INCORPORATING DISTURBANCE CONTROL SOFTWARE AND VIBRATION ISOLATION HARDWARE TO IMPROVE CONTROL PERFORMANCE FOR FLEXIBLE STRUCTURAL SYSTEMS.

JPL

TDMX 2413: DYNAMIC DISTURBANCE

(VOLUME 11)





ACCOMMODATION REQUIREMENTS

EXPERIMENT TITLE: TDMX 2413 - DYNAMIC DISTURBANCE

PRINCIPAL INVSTIGATOR(S): RAYMOND WOO/DR. NEVILLE MARZWELL

ADDRESS: BUILDING 198 ROOM 326

PROPOSED FLIGHT DATE 1993 YEAR(S)

OPERATIONAL DAYS REQUIRED 90 (PER YEAR)

MASS 290 KG

VOLUME: 30. M^3

	W		x L		x H		=		
STORED	W	4.	x L	3.	x H	2.5	=	30.	M3
DEPLOYED	W	15.	x L	15.	x H	20	=	4500	M3

INTERNALLY ATTACHED NO (YES/NO)
EXTERNALLY ATTACHED YES (YES/NO)
FORMATION FLYING NO (YES/NO)

ORIENTATION (inertial, solar, earth, other) ______

EXTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days.	Interval
SET-UP:	24	1	
OPERATIONS:			
SERVICING:	12	1	30

INTRA-VEHICULAR ACTIVITY REQUIRED:

	Hrs/Day	No. of days.	Interval
SET-UP:	5	1	
OPERATIONS:	5	15	30
SERVICING:	10	1	30

POWER REQUIRED:

3.50AC/1.40DC KW AC & DC ~~AC or DC~~ (circle one)

5 Hrs/Day 90 No. of days

DATA RATE: .01 Megabits/second

DATA STORAGE: .170 Gigabits

S3-18

DISTRIBUTED CONTROL

RAYMOND WOO/DR. NEVILLE MARZWELL

OCTOBER 8-9-10, 1985

IN-SPACE RESEARCH, TECHNOLOGY & ENGINEERING WORKSHOP

WILLIAMSBURG, VIRGINIA

EXPERIMENT OBJECTIVES:

O TECHNOLOGY
- DEMONSTRATE AND EVALUATE DISTRIBUTED CONTROL TECHNOLOGY/TECHNIQUES DEVELOPED FOR LFSS
- VALIDATING SENSING STRATEGIES, CONTROL HARDWARE, DISTRIBUTED CONTROL ALGORITHM AND MECHANIZATION
- EVALUATE OVERALL SYSTEM CONTROL PERFORMANCE AND STABILITY IN ON-ORBIT ENVIRONMENT

O SPACE STATION
- PROVIDE TECHNOLOGY FOR DISTRIBUTED CONTROL OF SPACE STATION LARGE FLEXIBLE STRUCTURES.
- CHARACTERIZED BY SPECIALIZED FACILITIES SUPPORT FOR LARGE SCALE EXPERIMENTATION WITH SPACE STRUCTURES (POWER/THERMAL, COMMUNICATION, DATA PROCESSING, FLEXIBLE PAYLOAD ACCOMMODATIONS/STORAGE, MANPOWER)

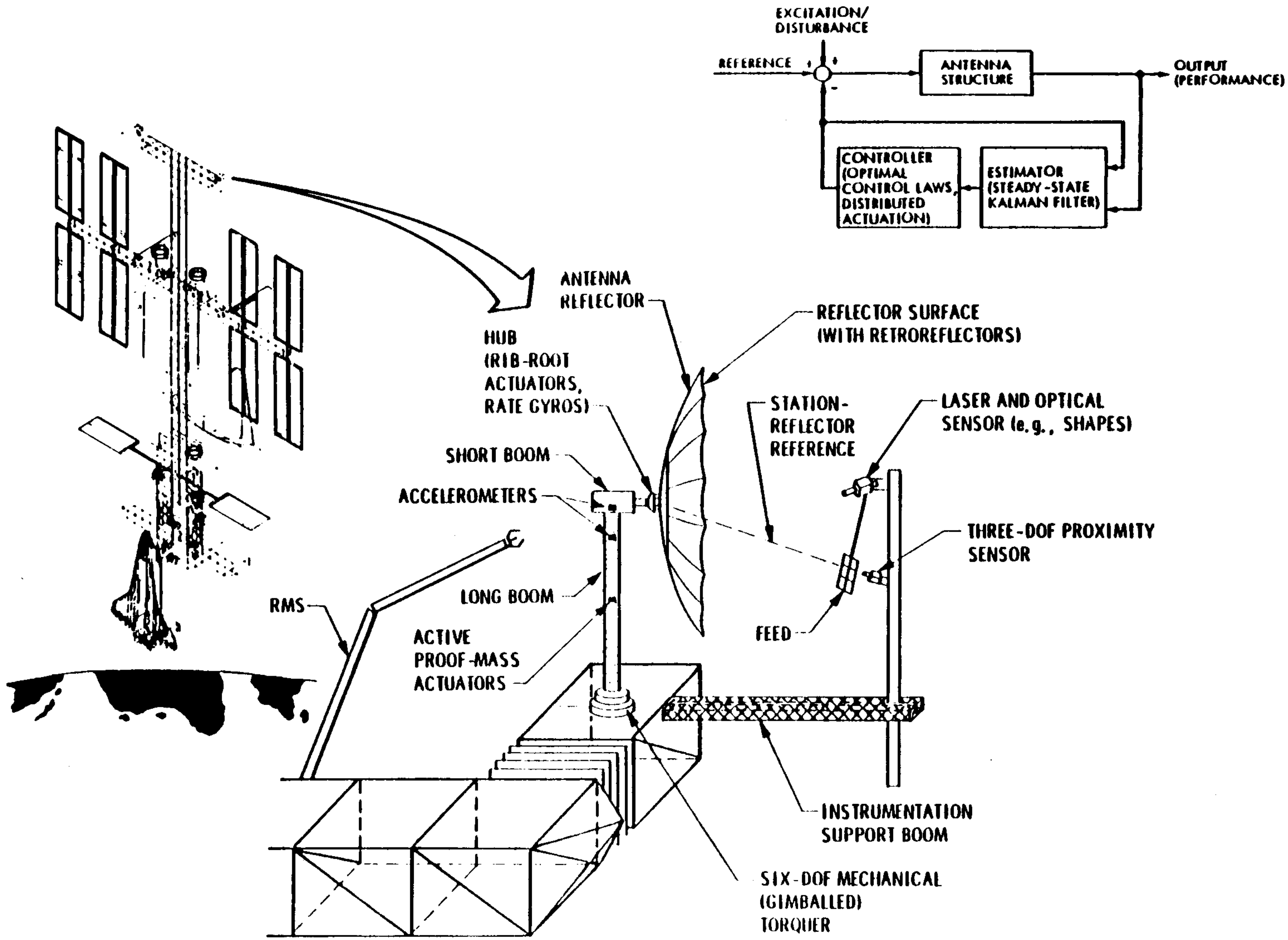
- FLIGHT EXPERIMENT 1: BASIC DEMONSTRATION
  - DEPLOY AN ANTENNA STRUCTURE AS A STRAWMAN TEST ARTICLE FOR EXPERIMENTATION
  - STIMULATE OR EXCITE STRUCTURAL MODES BY ROTATING THE ANTENNA REFLECTOR DISH AT THE HUB, AND BY SLEWING THE ENTIRE ANTENNA STRUCTURE AT A MODERATE RATE.
  - OBSERVE THE STIMULATED STRUCTURAL MODES AND DAMPING CHARACTERISTICS WITH AND WITHOUT CLOSED-LOOP FEEDBACK CONTROL ACTUATION GOVERNED BY DISTRIBUTED CONTROL LAWS/ALGORITHMS.
  - ACTUATORS AND SENSORS MAY BE RECONFIGURED FOR CONTROL PERFORMANCE IMPROVEMENT IN REPEATED EXPERIMENTATION IF DEEMED NECESSARY.

- FLIGHT EXPERIMENT 2: STRONG DISTURBANCE INPUT DEMONSTRATION
  - VERY SIMILAR TO THAT IN EXPERIMENT 1, EXCEPT THAT FORCING DEVICES ARE TO BE INSTALLED ALONG THE ANTENNA BOOMS AND THE REFLECTOR DISH HUB.
  - LEVEL OF EXCITATIONS WILL BE INCREASED WITH THE CONTROLLED AND CALIBRATED USE OF THE FORCING DEVICES
  - OBSERVE THE RESPONSES OF THE SYSTEM WITH AND WITHOUT CLOSED-LOOP DISTRIBUTED CONTROL ACTUATION.
  - COMPARE EXPERIMENT OUTCOME TO THE RESULTS OBTAINED IN EXPERIMENT 1 TO ASSESS AND EVALUATE MORE FULLY THE EFFECTIVENESS OF IMPLEMENTING DISTRIBUTED CONTROL TECHNIQUES AND ALGORITHMS FOR STRUCTURAL CONTROL.

JPL

TDMX 2412: DISTRIBUTED CONTROL EXPERIMENT

(VOLUME 10)



ACCOMMODATION REQUIREMENTS

EXPERIMENT TITLE: TDMX 2412 - DISTRIBUTED CONTROL

PRINCIPAL INVSTIGATOR(S): RAYMOND WOO/DR. NEVILLE MARZWELL

ADDRESS: BUILDING 198 ROOM 326

PROPOSED FLIGHT DATE 1993 YEAR(S)

OPERATIONAL DAYS REQUIRED 90 (PER YEAR)

MASS 270. KG

VOLUME: 21 M^3

STORED	W	5	x L	2.1	x H	2	= 2.1	M3
DEPLOYED	W	15.	x L	15.	x H	20.	= 4500.	M3

INTERNALLY ATTACHED NO (YES/NO)
EXTERNALLY ATTACHED YES (YES/NO)
FORMATION FLYING NO (YES/NO)

ORIENTATION (inertial, solar, earth, other) ______

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	24	Hrs/Day	[illegible]	No. of days.		
OPERATIONS:		Hrs/Day		No. of days.		Interval
SERVICING:	12	Hrs/Day	1	No. of days.	30	Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	5	Hrs/Day	1	No. of days.		
OPERATIONS:	5	Hrs/Day	15	No. of days.	30	Interval
SERVICING:	10	Hrs/Day	1	No. of days.	30	Interval

POWER REQUIRED:

1.400 KW AC & DC ~~AC or DC~~ (circle one)

5 Hrs/Day 90 No. of days

DATA RATE: .01 Megabits/second

DATA STORAGE: .142 Gigabits

ADVANCED ADAPTIVE CONTROL

RAYMOND WOO/DR. NEVILLE MARZWELL

OCTOBER 8-9-10, 1985

IN-SPACE RESEARCH, TECHNOLOGY & ENGINEERING
WORKSHOP

WILLIAMSBURG, VIRGINIA

EXPERIMENT OBJECTIVES:

- TECHNOLOGY
  - DEMONSTRATE AND EVALUATE ADVANCED ADAPTIVE CONTROL TECHNOLOGY/TECHNIQUES FOR LFSS.
  - ASSESSING AND VALIDATING SENSING STRATEGIES, CONTROL HARDWARE, ADAPTIVE CONTROL ALGORITHM, MECHANIZATION.
  - EVALUATE OVERALL SYSTEM CONTROL PERFORMANCE AND STABILITY IN AN ON-ORBIT ENVIRONMENT.

- SPACE STATION
  - PROVIDE TECHNOLOGY FOR ADAPTIVE CONTROL OF SPACE STATION LARGE FLEXIBLE STRUCTURES.
  - CHARACTERIZE SPECIALIZED FACILITIES SUPPORT FOR LARGE SCALE EXPERIMENTATION WITH SPACE STRUCTURES (POWER/THERMAL, COMMUNICATION, DATA PROCESSING, FLEXIBLE PAYLOAD ACCOMMODATIONS/STORAGE, MANPOWER).

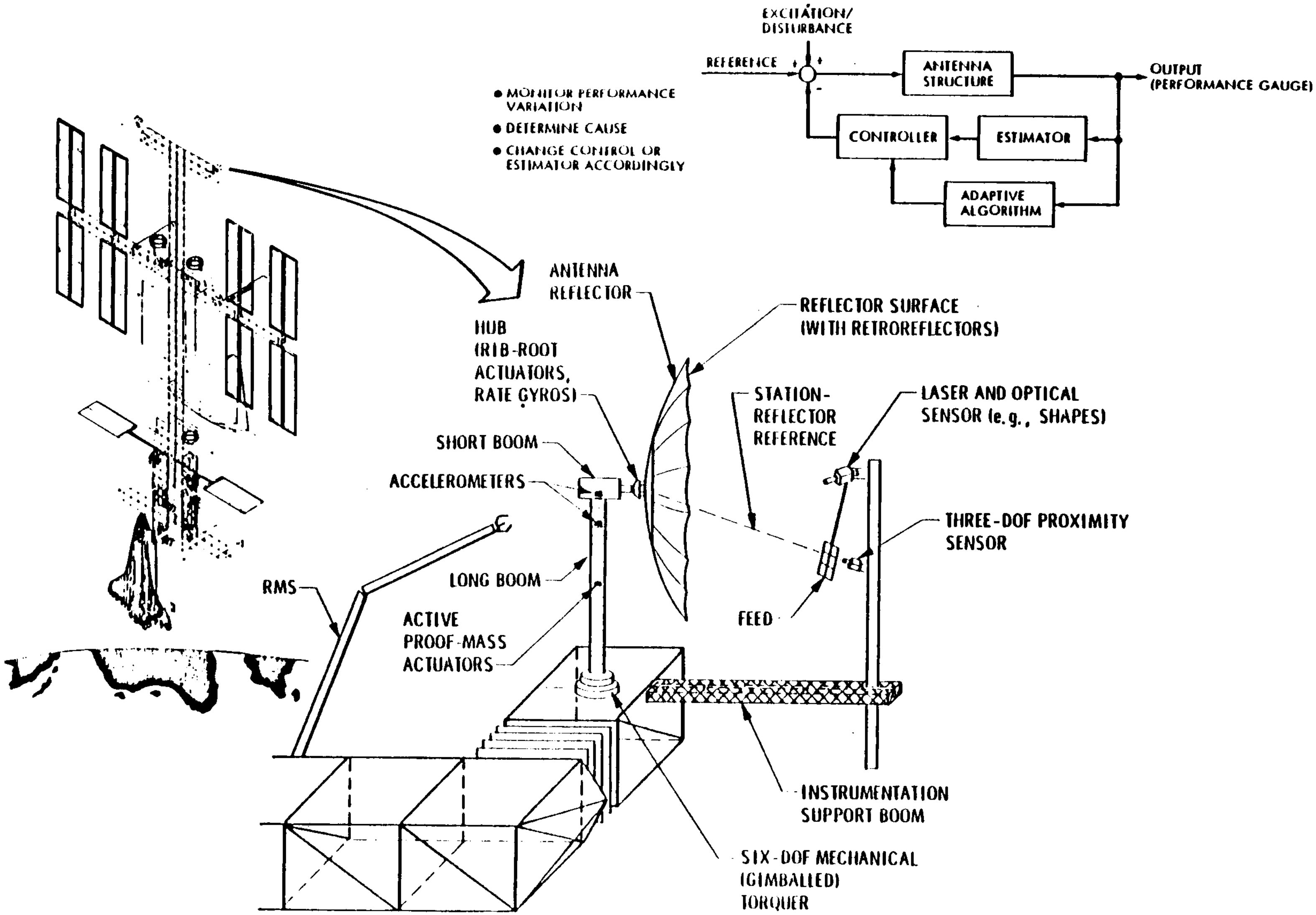
- EXPERIMENT 1: BASE DEMONSTRATION

    - DEPLOY AN ANTENNA STRUCTURE AS A STRAWMAN TEST ARTICLE FOR EXPERIMENTATION.
    - STIMULATE OR EXCITE STRUCTURAL MODES BY ROTATING THE ANTENNA REFLECTOR DISH AT THE HUB, AND BY SLEWING THE ENTIRE ANTENNA STRUCTURE AT A MODERATE RATE.
    - OBSERVE THE STIMULATED STRUCTURAL MODES AND DAMPING CHARACTERISTICS WITH AND WITHOUT FEEDBACK CONTROL ACTUATION GOVERNED BY ADVANCED ADAPTIVE CONTROL LAWS/ALGORITHMS.
    - ACTUATORS AND SENSORS MAY BE RECONFIGURED FOR CONTROL PERFORMANCE IMPROVEMENT IN REPEATED EXPERIMENTATION IF DEEMED NECESSARY.

- EXPERIMENT 2: STRONG DISTURBANCE INPUT DEMONSTRATION

    - VERY SIMILAR TO THAT IN EXPERIMENT 1, EXCEPT THAT FORCING DEVICES ARE TO BE INSTALLED ALONG THE ANTENNA BOOMS AND IN THE REFLECTOR DISH HUB.
    - LEVEL OF EXCITATIONS WILL BE INCREASED WITH THE CONTROLLED AND CALIBRATED USE OF THE FORCING DEVICES.
    - OBSERVE THE RESPONSES OF THE SYSTEM WITH AND WITHOUT FEEDBACK CONTROL ACTUATION GOVERNED BY ADVANCED ADAPTIVE CONTROL LAWS/ALGORITHMS.
    - COMPARE EXPERIMENT OUTCOME TO THE RESULTS OBTAINED IN EXPERIMENT 1 TO ASSESS AND EVALUATE MORE FULLY THE EFFECTIVENESS OF MECHANIZING ADAPTIVE CONTROL TECHNIQUES AND ALGORITHMS FOR STRUCTURAL CONTROL.

TDMX 2411: ADVANCED ADAPTIVE CONTROL
(VOLUME 9)



ACCOMMODATION REQUIREMENTS

EXPERIMENT TITLE: TDMX 2411- ADVANCED ADAPTIVE CONTROL

PRINCIPAL INVSTIGATOR(S): RAYMOND WOO/DR. NEVILLE MARZWELL

ADDRESS: BUILDING 198 ROOM 326

PROPOSED FLIGHT DATE 1992 YEAR(S)

OPERATIONAL DAYS REQUIRED 90 (PER YEAR)

MASS 270 KG

VOLUME: 21. M^3

STORED W 5. x L 2.1 x H 2 = 21. M3

DEPLOYED W 15. x L 15. x H 20. = 4500. M3

INTERNALLY ATTACHED NO (YES/NO)
EXTERNALLY ATTACHED YES (YES/NO)
FORMATION FLYING NO (YES/NO)

ORIENTATION (inertial, solar, earth, other) ______

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	24	Hrs/Day	1	No. of days.		
OPERATIONS:		Hrs/Day		No. of days.		Interval
SERVICING:	12	Hrs/Day	1	No. of days.	30	Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	5	Hrs/Day	1	No. of days.		
OPERATIONS:	5	Hrs/Day	15	No. of days.	30	Interval
SERVICING:	10	Hrs/Day	1	No. of days.	30	Interval

POWER REQUIRED:

1.400 KW AC & DC ~~AC or DC~~ (circle one)

5 Hrs/Day 90 No. of days

DATA RATE: .01 Megabits/second

DATA STORAGE: .142 Gigabits

ATTITUDE CONTROL AND ENERGY EXPERIMENT

E. RODRIGUEZ (GSFC/U OF MD)

OBJECTIVE

- o FLIGHT QUALIFICATION OF A NEW APPROACH COMBINING ATTITUDE CONTROL AND LONG-LIFE ENERGY STORAGE
- o A VIABLE OPTION FOR PLATFORM GROWTH REQUIREMENTS

RATIONALE

ATTITUDE CONTROL SYSTEMS HAVE EFFECTIVELY UTILIZED ROTATING SYSTEMS SINCE THE EARLY DAYS OF SPACEFLIGHT. A GIVEN MOMENTUM STORAGE NEED CAN BE MET BY SMALLER/LIGHTER WHEELS OPERATING AT HIGHER SPEEDS.

- o VERY HIGH SPEEDS ARE OBTAINABLE WITH HIGH STRENGTH FILAMENTARY WOUND COMPOSITE ROTORS.
- o LONG LIFE, INDEPENDENT OF OPERATING SPEED, CAN BE OBTAINED WITH NON-CONTACTING MAGNETIC SUSPENSIONS.
- o EFFICIENT ELECTRO-MECHANICAL ENERGY CONVERSION IS VITAL TO HIGH SPEED REACTION WHEELS AND TO ENERGY STORAGE WHEELS.

THE EXPERIMENTS CAN ACHIEVE MOST OF ITS TEST OBJECTIVES IN A 30 DAY TEST AFTER WHICH IT COULD SERVE AS SUPPLEMENTAL ENERGY STORAGE OPERATIONALLY. A SIGNIFICANT TEST BENEFIT WOULD CHECK-OUT THE U.P.C. (UTILITY POWER CONDITIONER) WHICH IS PRESENTLY CONCEIVED AS A BIDIRECTIONAL POWER INTERFACE WHICH, IN TURN, WOULD VERIFY A SPACE STATION GROWTH CAPABILITY.

THE ACES (ATTITUDE CONTROL AND ENERGY STORAGE SYSTEM) FOR WHICH THE PROPOSED EXPERIMENT IS A PROTOTYPE, IS A FOUR (MINIMUM) REACTION WHEEL SYSTEM CAPABLE OF THREE AXIS ATTITUDE CONTROL AND ENERGY STORAGE BY MOMENTUM EXCHANGE AND CHARGE/DISCHARGE RATE CONTROL ON ALL FOUR WHEELS.

ATTITUDE CONTROL AND ENERGY EXPERIMENT

E. RODRIGUEZ (GSFC/ U OF MD)

DESCRIPTION

- o COUNTER-ROTATING, SOLID, FIBER-WOUND COMPOSITE FLYWHEELS
- o LARGE DIAMETER MAGNETIC BEARINGS FOR SPOKELESS, SHAFTLESS CONSTRUCTION
- o INTEGRAL IRONLESS ARMATURE MOTOR/GENERATOR FOR EFFICIENT HIGH SPEED OPERATION
- o EFFICIENT ALL SOLID-STATE SENSING, POWER SWITCHING AND CONVERSION ELECTRONICS

THE RESULT IS A NEARLY MONLOTHIC WHEEL, WITH NO KNOWN WEAR-OUT PHENOMENA, WHICH CAN BE SPUN UP AND DISCHARGED WITHOUT DISTURBING THE A.C.S. BUT WHICH CAN BE EXPERCISED TO PRODUCE CONTROL TORGUES ON DEMAND BY DIFFERENTIAL SPEED CONTROL.

THE DEVICE SHOULD BE "TRANSPARENT" TO THE POWER SYSTEM, THAT IS IT SHOULD ACT EXACTLY LIKE A BATTERY--ACCEPTING AND PROVIDING POWER. IT WILL, HOWEVER, HAVE EASILY MONITORED STATE-OF-CHARGE (WHEEL SPEED), GREATER ALLOWABLE TEMPERATURE RANGE, AND NO LIMITATION ON NUMBER OF CYCLES.

THE ACES PROGRAM IS BEING PERFOREMD AT THE UNIVERSITY OF MARYLAND UNDER THE DIRECTION OF DRS. D. ANAND AND J. KIRK, THE GSFC CONTACT IS MR. E. RODRIGUEZ.

EXPERIMENT TITLE: ATTITUDE CONTROL AND ENERGY EXPERIMENT (E. RODRIGUEZ - GSFC/U OF MD)

PROPOSED FLIGHT DATE - 1992 **YEAR**

OPERATIONAL DAYS REQUIRED - 30+

MASS - 100 **KG**

VOLUME:

STORED W 0.5 x L 1.0 x H 0.5 = 0.25 M^3

DEPLOYED W ____ x L ____ x H ____ = ____ M^3

INTERNALLY ATTACHED Y (YES/NO)
EXTERNALLY ATTACHED OR Y (YES/NO)
FORMATION FLYING N (YES/NO)

ORIENTATION (inertial, solar, earth, other) NONE

EXTRA-VEHICULAR ACTIVITY REQUIRED: NONE

SET-UP:		Hrs/Day		No. of days		
OPERATIONS:		Hrs/Day		No. of days		Interval
SERVICING		Hrs/Day		No. of days		Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	2	Hrs/Day	2	No. of days		
OPERATIONS:	0.05	Hrs/Day	30	No. of days	DAILY	Interval
SERVICING	0	Hrs/Day	0	No. of days		Interval

POWER REQUIRED:

1.0 PD, 0.1 AVE. KW AC or DC (circle one)

24 Hrs/Day ____ No. of days

DATA RATE: TBD Megabits/second

DATA STORAGE: TBD Gigabits

JPL

LARGE SPACE REFLECTORS FLIGHT EXPERIMENTS ON THE SPACE STATION

ROBERT E. FREELAND
JOHN C. MANKINS

OCTOBER 8, 9, & 10, 1985
IN-SPACE RESEARCH, TECHNOLOGY & ENGINEERING (RT&E) WORKSHOP

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o EXPERIMENT OBJECTIVES:

- TECHNOLOGY. TO DEMONSTRATE AND EVALUATE LARGE SPACE REFLECTOR TECHNOLOGY, INCLUDING STRUCTURAL AND CONTROL PERFORMANCE FOR FLEXIBLE SYSTEMS; AND SUPPORTING ON-ORBIT RF TESTING AND DYNAMIC SYSTEM CHARACTERIZATION.

- SPACE STATION. TO SUPPORT DEVELOPMENT OF SPACE STATION CAPABILITY TO REDUCE THE RISK AND IMPROVE THE PERFORMANCE OF USING LARGE, COMPLEX, DEPLOYED/ASSEMBLED STRUCTURAL SYSTEMS.

JPL

LARGE SPACE REFLECTORS FLIGHT EXPERIMENTS ON THE SPACE STATION

o DESCRIPTION:

- EXPERIMENT 1: DEPLOYMENT RISK REDUCTION.
  - o EXAMINE/DEMONSTRATE "INITIAL NOMINAL DEPLOYMENT" OF 5-10 PERCENT TO VERIFY MECHANICAL DEPLOYMENT SYSTEMS.
  - o RE-STOW (FULL OR PARTIAL) DEPLOYABLE ANTENNA FOR BOOST TO GEO, FULL DEPLOYMENT, AND UTILIZATION.

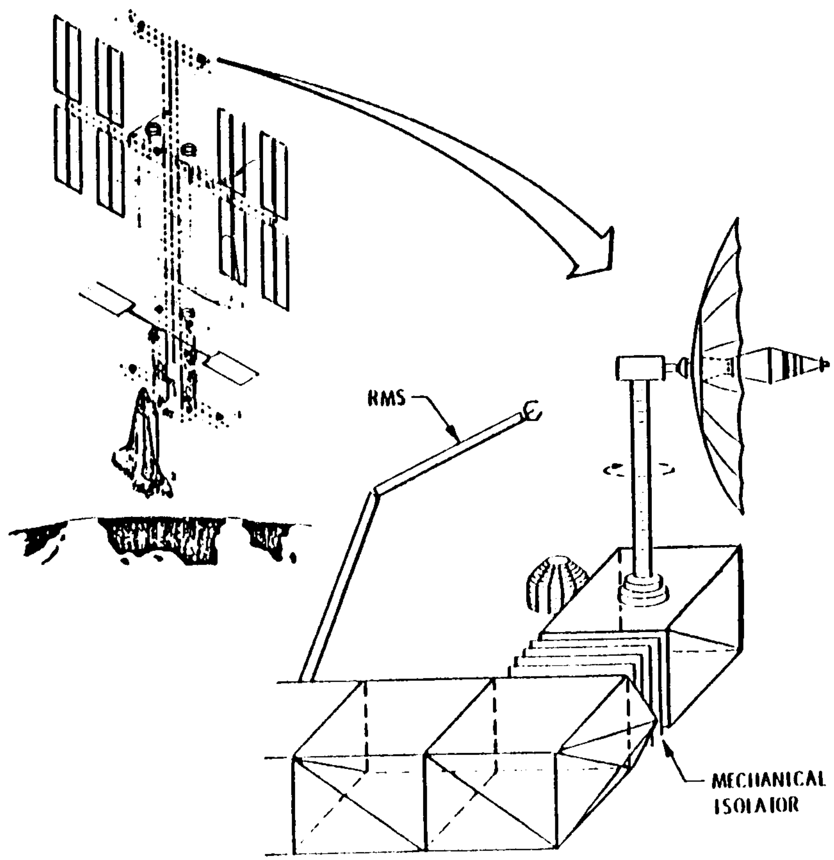
- EXPERIMENT 2: DEPLOYABLE ANTENNA PERFORMANCE VERIFICATION.
  - o EXAMINE/DEMONSTRATE "FULL DEPLOYMENT;" EVALUATE MECHANICAL CHARACTERISTICS, RF PERFORMANCE, ETC; AND CORRECT APERTURE PRECISION AND FEED STRUCTURE ALIGNMENT AS REQ'D.
  - o TRANSPORT TO GEO, OPEN AT LOW-THRUST, OR PARTIALLY RE-STOWED.

- EXPERIMENT 3: ON-ORBIT SYSTEM ASSEMBLY, ASSESSMENT AND ADJUSTMENT.
  - o DEVELOP HYBRID TECHNOLOGY ANTENNAS; INVOLVING MODULAR, DEPLOYABLE STRUCTURE AND IN-SPACE ASSEMBLY OF STRUCTURAL ELEMENTS (E.G., LDR)
  - o EVALUATE PERFORMANCE, INCLUDING MECHANICAL, AND CORRECT AS REQ'D.
  - o TRANSPORT OF OPERATING ORBIT, FULLY OPEN, AT LOW-THRUST.

JPL

LARGE SPACE REFLECTORS FLIGHT EXPERIMENTS ON THE SPACE STATION

ILLUSTRATION



ACCOMMODATION REQUIREMENTS

EXPERIMENT TITLE: LARGE SPACE REFLECTORS FLIGHT EXPERIMENTS

PRINCIPAL INVSTIGATOR(S): Robert F. Freeland

ADDRESS: Jet Propulsion Laboratory; Pasadena, CA

PROPOSED FLIGHT DATE 1993, 1994, 1996, 1997 YEAR(S)

OPERATIONAL DAYS REQUIRED 15 (PER YEAR)

MASS 3000 KG

VOLUME:

STORED W 9.0 x L 4.0 x H 5.0 = 180.0 M3

DEPLOYED W 30.0 x L 30.0 x H 10.0 = 9000.0 M3

INTERNALLY ATTACHED yes (YES/NO)
EXTERNALLY ATTACHED yes (YES/NO)
FORMATION FLYING ____ (YES/NO)

ORIENTATION (inertial, solar, earth, other) other

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	6.0	Hrs/Day	12	No. of days.		
OPERATIONS:	0.0	Hrs/Day		No. of days.	---	Interval
SERVICING:	6	Hrs/Day	1	No. of days.	120	Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	3.0	Hrs/Day	12	No. of days.		
OPERATIONS:	4.0	Hrs/Day	5	No. of days.	120	Interval
SERVICING:	3.0	Hrs/Day	1	No. of days.	120	Interval

POWER REQUIRED:

1.0 KW AC or DC (circle one)

4.0 Hrs/Day 5 No. of days

DATA RATE: 0.10 Megabits/second

DATA STORAGE: 0.20 Gigabits

TDMX 2061 - LARGE SPACE STRUCTURES

OBJECTIVE:

LARGE SPACE STRUCTURES (LSS) TECHNOLOGY DEMONSTRATION:

- LSS DEPLOYMENT AND ASSEMBLY
- DYNAMIC AND THERMAL BEHAVIOR OF A LARGE DEPLOYABLE TRUSS
- SUBSYSTEM INSTALLATION AND CHECKOUT
- DEMONSTRATION OF MAN'S ROLE AND CAPABILITIES IN SPACE

FOLLOWING THE TDM, THIS STRUCTURE WILL SERVE AS A PERMANENT SPACE STATION FACILITY.

DESCRIPTION:

THE CONSTRUCTION/STORAGE/HANGAR FACILITY IS A LARGE DEPLOYABLE TRUSS PLATFORM ATTACHED TO THE SPACE STATION WHICH CAN BECOME A PERMANENT SPACE STATION FACILITY. THE TRUSS IS DEPLOYED AND ATTACHED TO THE SPACE STATION EITHER DIRECTLY OR BY A TRANSFER TUNNEL LOCATED AT THE CENTER OF THE TRUSS. SUBSYSTEM COMPONENTS SUCH AS UTILITY CABLES, ATTACHMENT FIXTURES, STORAGE LOCKERS, FLOOR PANELS, MANIPULATORS, WORKSTATIONS AND THE HANGAR PANELS ARE THEN ATTACHED. TESTS AND MEASUREMENTS ARE ACCOMPLISHED THROUGHOUT THE DEPLOYMENT AND ASSEMBLY PROCESS TO DETERMINE STRUCTURAL ACCURACIES AND TO DETERMINE THERMAL AND DYNAMIC CHARACTERISTICS OF A LARGE DEPLOYABLE TRUSS.

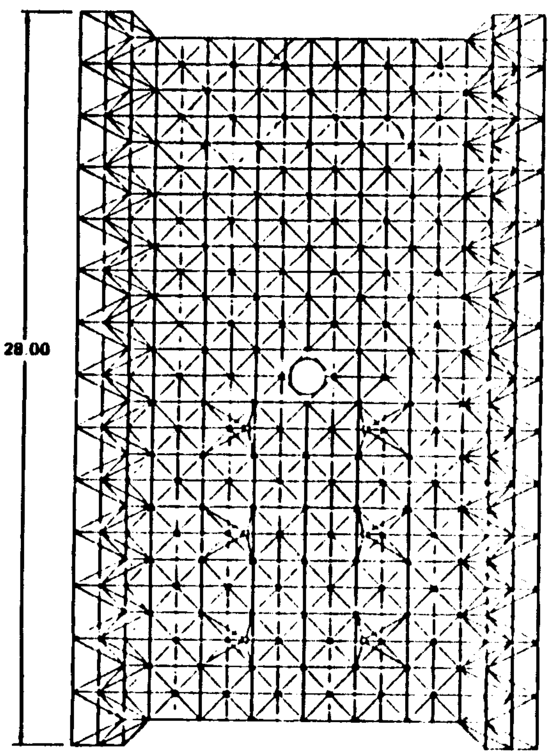
ITS ULTIMATE USE WOULD BE TO PROVIDE A SATELLITE AND OTV ASSEMBLY, CHECKOUT AND SERVICING AREA AS WELL AS A LOCATION FOR THE STORAGE OF COMPONENTS, MATERIALS, ASSEMBLY AIDS, AND TOOLS. A PAIR OF RAILS SUPPORTED BY TRUSS MEMBERS DUPLICATE THE ORBITER BAY LONGERONS FOR THE STORAGE OF LARGE MODULES DELIVERED TO THE SPACE STATION. COMPARTMENTS INSTALLED WITHIN THE TRUSS MEMBERS PROVIDE STORAGE FOR SMALL ITEMS SUCH AS TOOLS, HOLD-DOWN MECHANISMS, AUXILIARY LIGHTS, ETC. SEGMENTS OF THE PLATFORM HAVE FLOOR PANELS INSTALLED TO PROVIDE STORAGE AREAS FOR SMALL MODULES AND OTHER EQUIPMENT. LIGHTWEIGHT HANGAR PANELS PROTECT THE CREW AND OTHER EQUIPMENT FROM SOLAR HEATING AND PROVIDE CONTAINMENT FOR UNTETHERED ASTRONAUTS AND SMALL OBJECTS. SOME OF THE HANGAR PANELS ARE PERMANENTLY ATTACHED TO THE PLATFORM WHILE THE "ROOF" IS RETRACTABLE, USING EXTENDABLE MASTS, TO ALLOW LARGE OBJECTS TO BE MANIPULATED USING THE SPACE STATION MRMS. THE HANGAR WILL CONTAIN LIGHTS FOR ILLUMINATION DURING EVA ACTIVITIES.

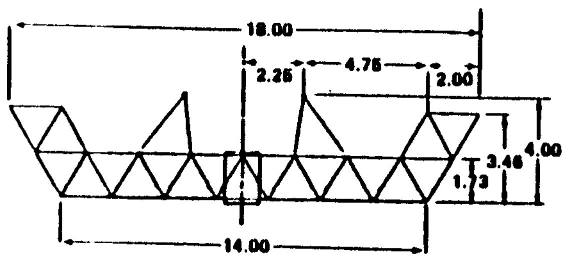
R. M. GATES

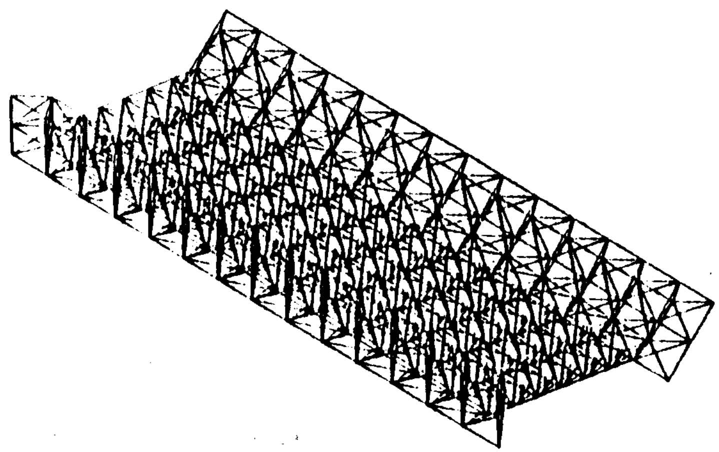
BOEING AEROSPACE COMPANY

SEATTLE, WASHINGTON

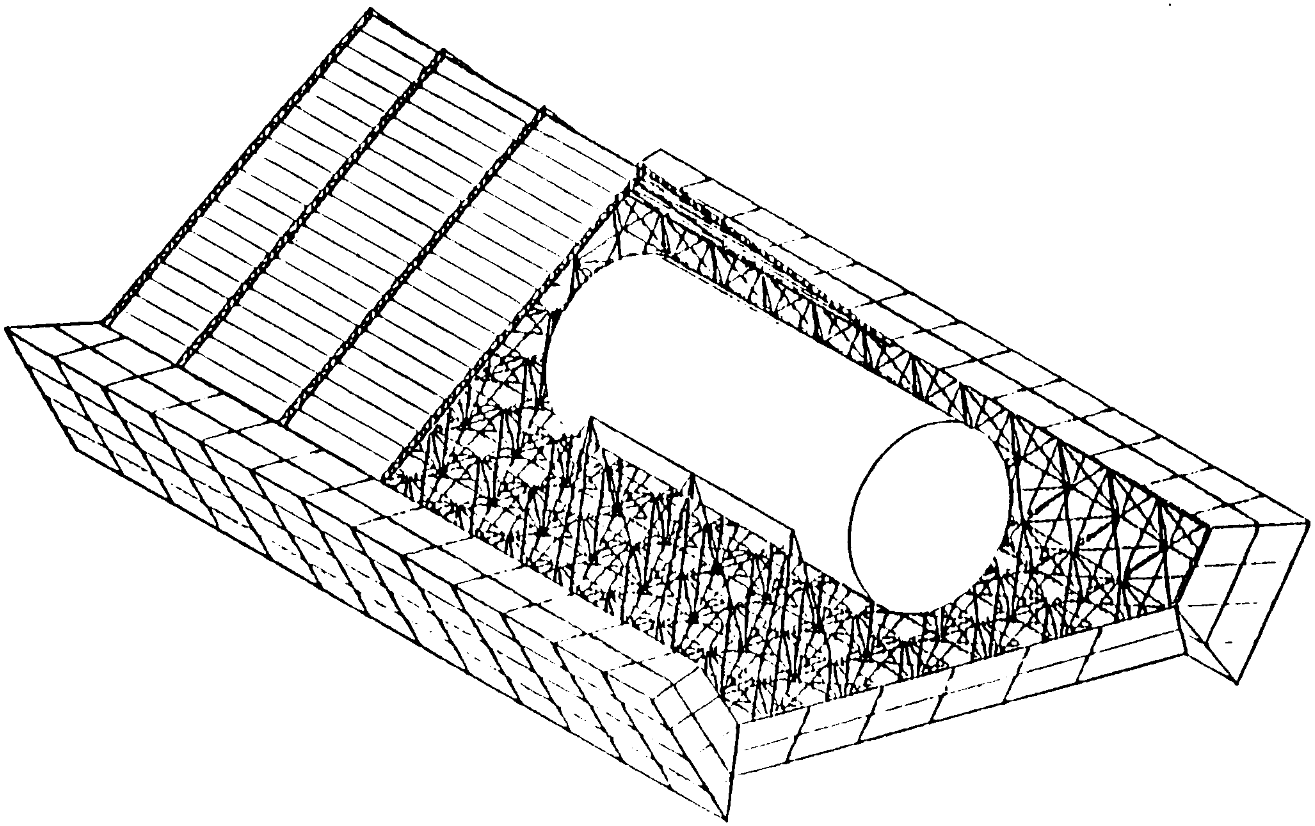
TDMX 2061 Large Space Structures
Construction/Storage/Hangar Facility







Construction/Storage/Hangar Facility



EXPERIMENT TITLE: TDMX 2061 Large Space Structures Construction/Storage/Hangar Facility

PROPOSED FLIGHT DATE - 1992 YEAR

OPERATIONAL DAYS REQUIRED - 12 (indefinite after setup)

MASS - 7000 KG

VOLUME:

STORED: W 4.5 (dia.) x L 6 x H ____ = 95 M^3

DEPLOYED: W 18 x L 28 x H 10 = 3030 M^3

INTERNALLY ATTACHED No (YES/NO)
EXTERNALLY ATTACHED Yes (YES/NO)
FORMATION FLYING No (YES/NO)

ORIENTATION (inertial, solar, earth, other) Any

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 6 Hrs/Day 9 No. of days

OPERATIONS: 6 Hrs/Day 3 No. of days 4 Interval

SERVICING: ____ Hrs/Day ____ No. of days ____ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 2 Hrs/Day 12 No. of days

OPERATIONS: 6 Hrs/Day 3 No. of days 4 Interval

SERVICING: ____ Hrs/Day ____ No. of days ____ Interval

POWER REQUIRED:

0.5 KW AC or DC (circle one)

6 Hrs/Day 12 No. of days

DATA RATE: 1 Megabits/second

DATA STORAGE: 0.2 Gigabits

SPACE STATION MODIFICATIONS

EXPERIMENT OBJECTIVE

TO DEMONSTRATE THE ABILITY TO EXPAND THE CAPABILITIES OF AN EVOLVING SPACE STATION BY PROVIDING A SERVICING SUPPORT AREA TO MODIFY/ EXPAND THE STATION. TO DEMONSTRATE THE CAPABILITY TO ASSEMBLE ON-ORBIT THE ELEMENTS REQUIRED TO PROVIDE A "SERVICING SUPPORT AREA" TO THE SPACE STATION.

SPACE STATION MODIFICATIONS

EXPERIMENT DESCRIPTION

THE EXPERIMENT IS AN ACTUAL SATELLITE SERVICING ACTIVITY REQUIRED TO ENSURE ASSEMBLY OF THE SPACE STATION "SATELLITE SERVICING SUPPORT AREA." THE TASK IS TO ASSEMBLE A SERVICING "STRONGBACK" AND ATTACH IT TO THE SPACE STATION. ONCE THIS IS ACCOMPLISHED, THE PRIMARY "SERVICING SUPPORT AREA" SERVICING ELEMENTS, I.E., THE SERVICE FACILITY/ HANGAR, SERVICE/MODULE STORAGE HANGAR, FUEL DEPOT AND OMV BERTHING MECHANISM WILL BE ATTACHED TO THE STRONGBACK. THIS ASSEMBLY TDM WILL REQUIRE TWO STS CARGO LOADS AND ALL ASSEMBLY SECTIONS WILL BE CARRIED TO THE SPACE STATION IN "RETURNABLE" CARGO CANISTERS. THE CARGO CANISTERS WILL BE ATTACHED TO THE SPACE STATION AND THE SPACE STATION REMOTE MANIPULATOR.

EXPERIMENT TITLE: TDM 2062 SPACE STATION MODIFICATIONS

PROPOSED FLIGHT DATE - 1992 YEAR

OPERATIONAL DAYS REQUIRED - ____________

MASS - ____________ KG

VOLUME:

STORED: W ______ x L ______ x H ______ = ______ M^3

DEPLOYED: W ______ x L ______ x H ______ = ______ M^3

INTERNALLY ATTACHED ______ (YES/NO)
EXTERNALLY ATTACHED ______ (YES/NO)
FORMATION FLYING ______ (YES/NO)

ORIENTATION (inertial, solar, earth, other) ____________

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ______ Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ______ Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

POWER REQUIRED:

______ KW AC or DC (circle one)

______ Hrs/Day ______ No. of days

DATA RATE: ______ Megabits/second

DATA STORAGE: ______ Gigabits

FIBER OPTIC SENSORS IN SPACE APPLICATIONS

MDAC-HB

W. OTAGURO
E. UDD
R. CAHILL

FIBER-OPTIC SENSORS IN SPACE APPLICATIONS

WILFRED S. OTAGURO
MDAC- H.B.

EXPERIMENTAL OBJECTIVE

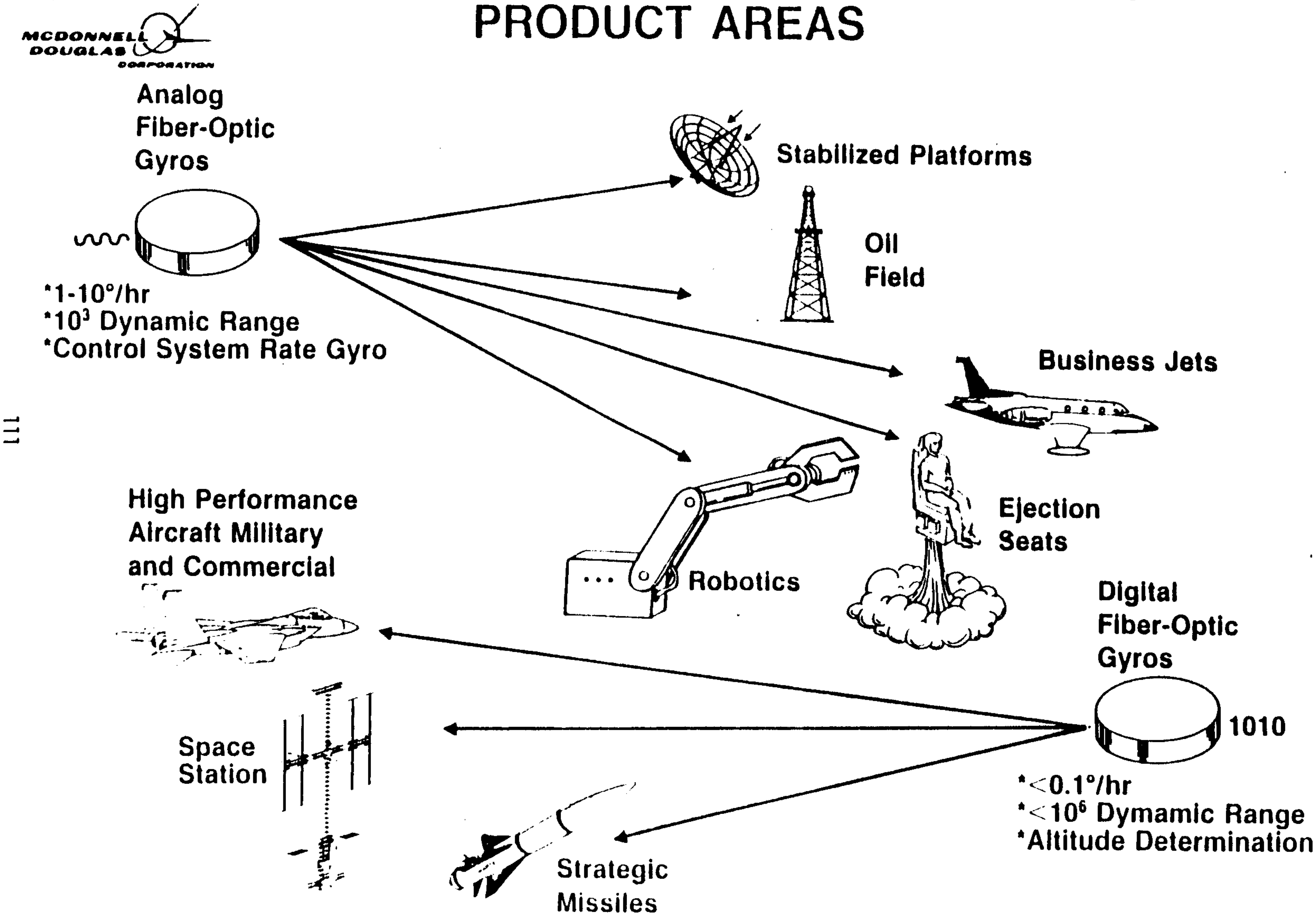
EVALUATE THE PERFORMANCE OF GENERIC INTERFEROMETRIC FIBER-OPTIC SENSORS USING COMMON MODULE BUILDUP IN TYPICAL SPACE APPLICATIONS. IN PARTICULAR, THE APPLICATION OF THE FIBER-OPTIC SAGNAC INTERFEROMETER GYRO IN CONTROL AND ATTITUDE DETERMINATION SYSTEMS AND THE FIBER-OPTIC MACH ZENHDER INTERFEROMETER AS AN ELONGATION/COMPRESSION STRUCTURE SENSOR WILL BE EXAMINED. THE PERFORMANCE, MAINTAINABILITY, RELIABILITY, AND OVERALL SYSTEM EFFECTIVENESS WILL BE ASSESSED BY DIRECT COMPARISONS WITH OTHER APPROACHES WHERE APPLICABLE.

EXPERIMENTAL DESCRIPTION

THE EXPERIMENT WILL DEMONSTRATE THE FEASIBILITY OF USING GENERIC INTERFEROMETRIC FIBER-OPTIC SENSORS IN SPACE APPLICATIONS BY INCORPORATING BOTH A FIBER-OPTIC GYRO AND A FIBER-OPTIC ELONGATION/COMPRESSION SENSOR ON PLATFORMS TO BE LAUNCHED IN THE 1990's. BESIDES EVALUATING THE PERFORMANCE OF THE COMMON MODULES WHICH MAKE UP THESE SENSORS, ENVIRONMENTAL PACKAGING ISSUES FOR SPACE APPLICATIONS WILL ALSO BE ADDRESSED. IN PARTICULAR, THE DESIGN OF THE FIBER-OPTIC SENSOR WILL EMPHASIZE THE FOLLOWING DESIRABLE FEATURES FOR SPACE APPLICATIONS: SMALL SIZE, LIGHTWEIGHT, LOW COST, LOW POWER REQUIREMENTS, ALL SOLID STATE (NO MOVING PARTS), ENVIRONMENTALLY HARDENED. WHERE PRACTICAL, THESE FIBER-OPTIC SENSORS WILL BE PIGGYBACKED WITH STANDARD HARDWARE AGAINST WHICH ITS PERFORMANCE AND EFFECTIVENESS WILL BE COMPARED AND EVALUATED.

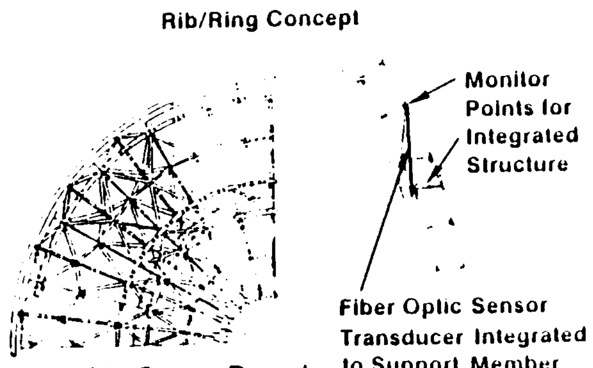
VGS202 1

ANALOG AND DIGITAL FIBER-OPTIC GYRO PRODUCT AREAS

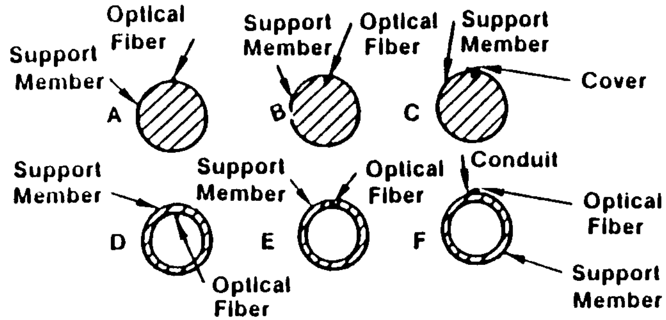


MCDONNELL DOUGLAS CORPORATION

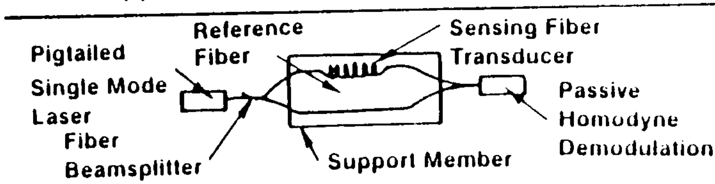
MDAC FIBER OPTIC ELONGATION/ COMPRESSON SENSOR



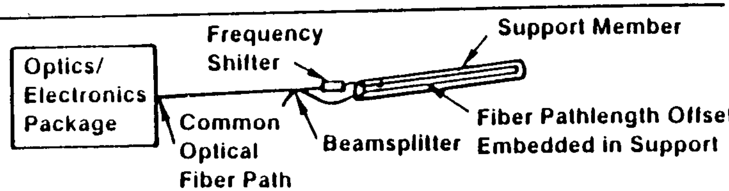
LDR Deployable Space Based Support Structure



Options for Integrating the Fiber Optic Transducer to Either a Support or Monitor Member

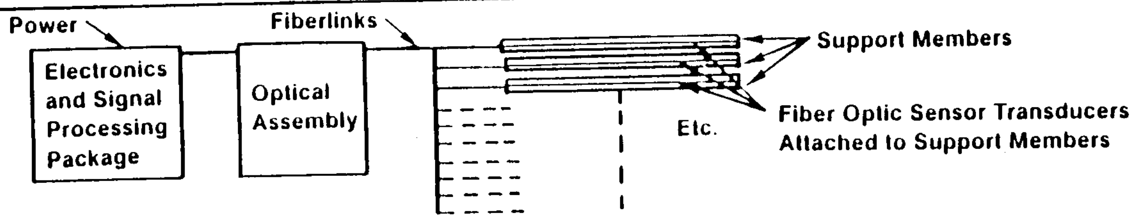


The Mach-Zehnder Fiber Interferometer Sensor



Common Path Sagnac Fiber Interferometer

Sensor Options



Modular Fiber Optic Sensor Packaging

EXPERIMENT TITLE: FIBER OPTIC SENSORS IN SPACE APPLICATIONS - WIL OTAGURO, MDAC-HB

PROPOSED FLIGHT DATE - ~~1990~~ YEAR

OPERATIONAL DAYS REQUIRED - AS AVAILABLE

MASS - 40 KG

VOLUME:

STORED W ______ x L ______ x H ______ = 0.03 M^3

DEPLOYED W ______ x L ______ x H ______ = 0.03 M^3

INTERNALLY ATTACHED ______ (YES/NO)
EXTERNALLY ATTACHED ______ (YES/NO)
FORMATION FLYING ______ (YES/NO)

ORIENTATION (inertial, solar, earth, other) ______

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 4 Hrs/Day 2 No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ______ Interval

SERVICING ______ Hrs/Day ______ No. of days ______ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ______ Interval

SERVICING ______ Hrs/Day ______ No. of days ______ Interval

POWER REQUIRED:

0.01 KW AC or DC (circle one)

24 Hrs/Day AS AVAIL No. of days

DATA RATE: ______ Megabits/second

DATA STORAGE: ______ Gigabits

VHK755

EVA LARGE STRUCTURE ASSEMBLY

R. Dellacamera

McDonnell Douglas Astronautics Company
Huntington Beach, CA 92647
Telephone: 714-896-5224

VHK756

EVA LARGE STRUCTURE ASSEMBLY

Experiment Objective: To validate large structures space assembly and maintenance EVA techniques that use minimum on-orbit support equipment. These techniques have been tested in 1-g and neutral buoyancy environments but have to be validated in the actual space environment to be applied to Space Station and other large structure efforts. If these tasks can be accomplished efficiently and quickly, they will have a favorable impact on the economics of constructing the station and subsequent assembly programs.

This would be a next generation experiment from the access/ease effort.

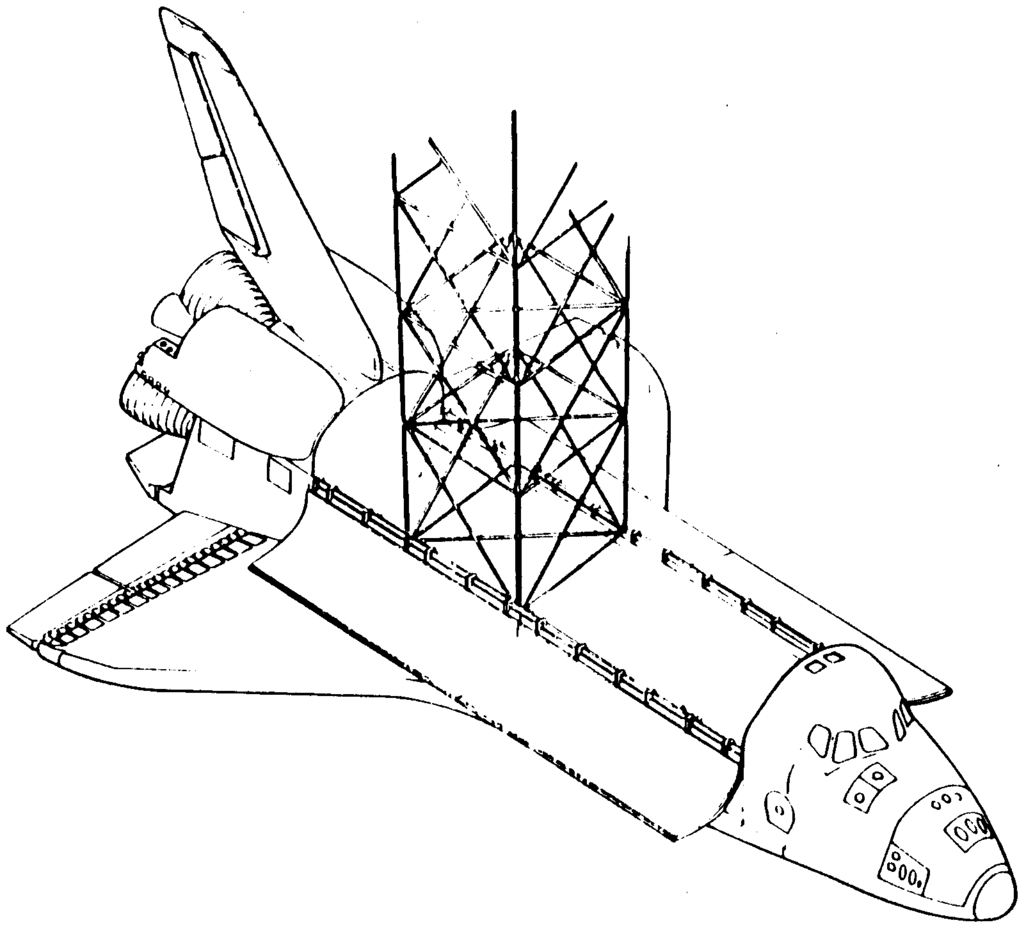
EVA LARGE STRUCTURE ASSEMBLY

Experiment Description: Assemble a 30-ft. section of erectable truss structure using individual struts, EVA-optimized connecting joints, and utility accommodations (electrical, fluids, gases, and data lines). This experiment would be accomplished with the EVA crewmen loosely restrained with tethers and use the RMS/MRMS to provide hardware management support. The crew would assemble the struts and nodes sequentially using the structure itself as a workstation. Utility runs would then be installed to complete the installation portion of the experiment.

A maintenance and servicing sequence would then be carried out. This would include replacing strut members that have simulated failures and servicing utilities (i.e., coolant loop recharge, stringing additional cabling, etc.)

VHK758

EVA LARGE STRUCTURE ASSEMBLY



EXPERIMENT TITLE: **EVA Large Structure Assembly**

PROPOSED FLIGHT DATE - **1988 & 1993** YEAR

OPERATIONAL DAYS REQUIRED - **1**

MASS - **≈100** KG

VOLUME:

STORED: W **1.6M** x L **4.6M** x H **1.6M** = **11.8** M^3

DEPLOYED: W **4.6M** x L **9.2M** x H **4.6M** = **194.6** M^3

INTERNALLY ATTACHED **No** (YES/NO)
EXTERNALLY ATTACHED **Yes** (YES/NO)
FORMATION FLYING **No** (YES/NO)

ORIENTATION (inertial, solar, earth, other) **Inertial Preferred**

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: **.25** Hrs/Day **1** No. of days

OPERATIONS: **1.0** Hrs/Day **1** No. of days ____ Interval

SERVICING: **1.0** Hrs/Day **1** No. of days ____ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED: **None**

SET-UP: ____ Hrs/Day ____ No. of days

OPERATIONS: ____ Hrs/Day ____ No. of days ____ Interval

SERVICING: ____ Hrs/Day ____ No. of days ____ Interval

POWER REQUIRED: **None**

____ KW AC or DC (circle one)

____ Hrs/Day ____ No. of days

DATA RATE: **22** Megabits/second

DATA STORAGE: **79.2** Gigabits

- **Full Motion Color Video (Digitized with Current State of the Art Compression)**
- **Analog Video an Acceptable Alternative**

TDMX 2064 - ADVANCED ANTENNA ASSEMBLY AND PERFORMANCE

OBJECTIVE:

LARGE SPACE STRUCTURES (LSS) TECHNOLOGY DEMONSTRATION:

- ON-ORBIT ASSEMBLY OF A LARGE ANTENNA SYSTEM
- DYNAMIC AND THERMAL BEHAVIOR OF A LARGE ANTENNA STRUCTURE
- MEMBRANE REFLECTOR SURFACE DEPLOYMENT AND INSTALLATION
- SUBSYSTEM INSTALLATION AND CHECKOUT
- SYSTEM IDENTIFICATION
- DEMONSTRATION OF MAN'S ROLE AND CAPABILITIES IN SPACE

FOLLOWING ITS USE AS A LSS TDM, THIS STRUCTURE CAN BE USED AS A TESTBED FOR OTHER EXPERIMENTS RELATING TO ANTENNA TECHNOLOGY.

DESCRIPTION:

THIS TDM INVOLVES THE CONSTRUCTION OF A 100 METER DIAMETER PASSIVE MICROWAVE RADIOMETER SENSOR. THE BASIC STRUCTURE IS A 103 METER DIAMETER ASSEMBLABLE TRUSS RING WHICH SUPPORTS A MESH MEMBRANE REFLECTOR SURFACE. A SYSTEM OF REINFORCING CABLES, SURFACE CONTROL CABLES AND ADJUSTMENT ACTUATORS PROVIDE SHAPE CONTROL FOR THE REFLECTOR. A DEPLOYABLE FEED ARRAY TRUSS BEAM IS SUPPORTED BY DEPLOYABLE TRUSS COLUMNS AND STABILIZED BY FOUR CABLES ATTACHED TO THE TRUSS RING. THE SUPPORT RING IS OF PENTAHEDRAL TRUSS CONSTRUCTION, UTILIZING TAPERED COLUMNS (18 METERS LONG) AS THE STRUCTURAL ELEMENTS. IT IS ASSEMBLED ELEMENT-BY-ELEMENT BY EVA ASTRONAUTS USING A TRACKED CONSTRUCTION FIXTURE ATTACHED TO THE SPACE STATION CONSTRUCTION PLATFORM. FOLLOWING THE ASSEMBLY OF EACH BAY OF THE RING, IT IS INDEXED ALONG THE FIXTURE TO ALLOW THE ASSEMBLY OF THE NEXT BAY. THIS PROCESS CONTINUES UNTIL THE RING IS COMPLETED. ACCURACY MEASUREMENTS AND DYNAMIC RESPONSE TESTS ARE CONDUCTED AT VARIOUS TIMES THROUGHOUT THE CONSTRUCTION PROCESS TO UNDERSTAND THE STRUCTURAL BEHAVIOR.

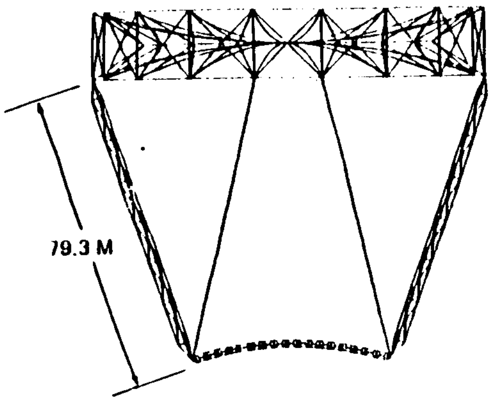
FOLLOWING ITS USE AS A LSS EXPERIMENT, IT CAN SERVE AS A TESTBED FOR THE ADVANCEMENT OF OTHER ANTENNA-RELATED TECHNOLOGIES SUCH AS MEMBRANE SURFACE MANAGEMENT AND SHAPE CONTROL, NEAR FIELD ANTENNA PATTERNS, MICROWAVE RADIOMETRY, SENSOR AND REFLECTOR DEVELOPMENT, AND POINTING CONTROL. IT MAY ALSO BE UTILIZED AS A FUNCTIONING SENSOR SYSTEM TO PERFORM EARTH RESOURCES MEASUREMENTS WHILE ATTACHED TO THE SPACE STATION OR AS A FREE-FLYER (AFTER THE ADDITION OF THE REQUIRED PROPULSION, ATTITUDE CONTROL, GUIDANCE, DATA SYSTEMS, ETC.).

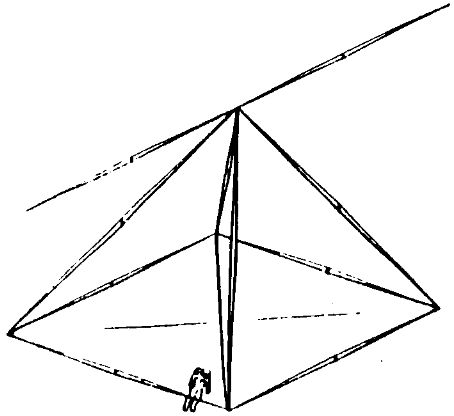
R. M. GATES

BOEING AEROSPACE COMPANY

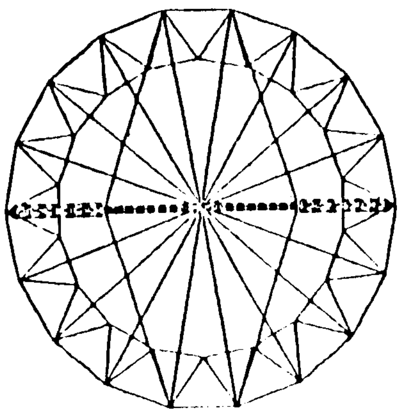
SEATTLE, WASHINGTON

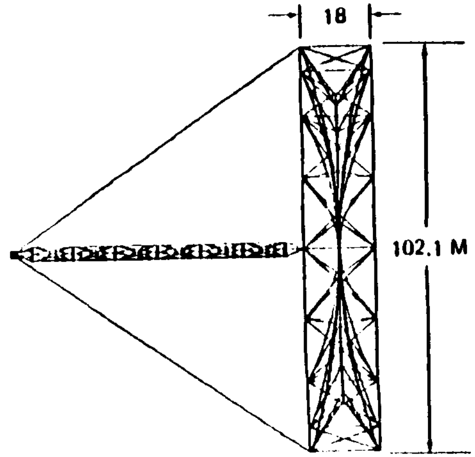
TDMX 2064 Advanced Antenna Assembly/Performance
Passive Microwave Radiometer



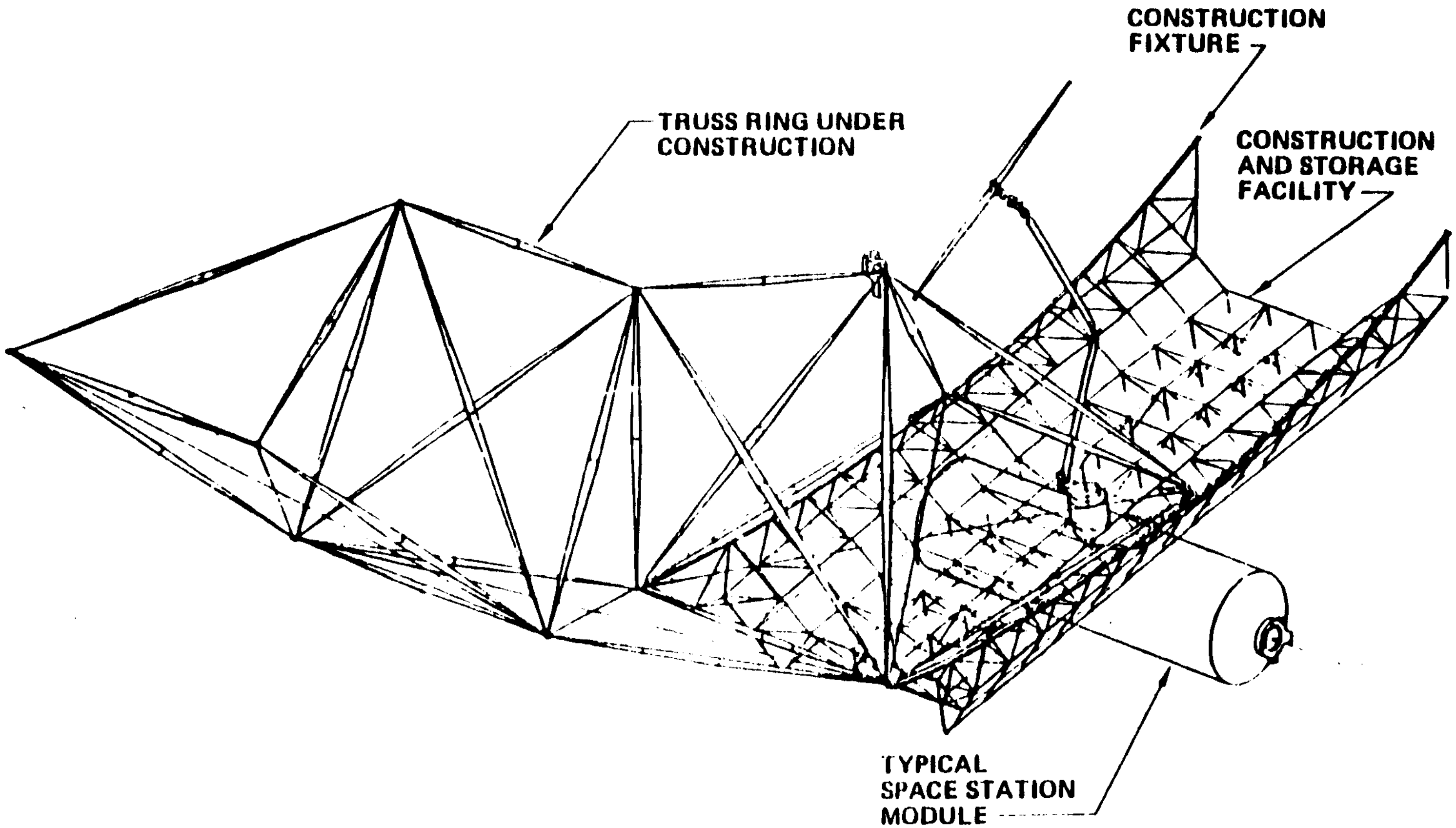


BASIC TRUSS ELEMENT





Radiometer Construction



EXPERIMENT TITLE: TDMX 2064 Advanced Antenna Assy/Perform.
Passive Microwave Radiometer

PROPOSED FLIGHT DATE - 1997 YEAR

OPERATIONAL DAYS REQUIRED - 33

MASS - 3000 KG

VOLUME:

STORED: W 4.5 (dia.) x L 13 x H ______ = 207 M^3

DEPLOYED: W 103 (dia.) x L 100 x H ______ = ______ M^3

INTERNALLY ATTACHED No (YES/NO)
EXTERNALLY ATTACHED Yes (YES/NO)
FORMATION FLYING No (YES/NO)

ORIENTATION (inertial, solar, earth, other) Any

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 6 Hrs/Day 27 No. of days

OPERATIONS: 6 Hrs/Day 6 No. of days 5 Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 2 Hrs/Day 33 No. of days

OPERATIONS: 6 Hrs/Day 6 No. of days 5 Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

POWER REQUIRED:

1 KW AC or DC (circle one)

6 Hrs/Day 33 No. of days

DATA RATE: 1 Megabits/second

DATA STORAGE: 0.2 Gigabits

NASA/MSFC

TDM 2063

ON-ORBIT SPACECRAFT ASSEMBLY/TEST

EXPERIMENT OBJECTIVE

TO DEMONSTRATE AND VERIFY FEASIBILITY OF ON-ORBIT ASSEMBLY AND TEST OF SPACECRAFT. THE SPACE STATION IS USED TO PROVIDE THE NECESSARY TIME SO THAT LONG DURATION EVENTS CAN BE HANDLED. THIS TDM WILL AUGMENT THE DEVELOPMENT OF TECHNOLOGIES SUCH AS: (1) CONSTRUCTION IN SPACE, (2) CONTAMINATION REMOVAL/CONTROL, (3) EVA, (4) IVA, (5) MANIPULATOR OPERATIONS, (6) ORU SERVICE/MAINTENANCE, (7) REFUEL, (8) TELEOPERATIONS, (9) TEST AND MEASUREMENT, (10) TETHER OPERATIONS AND (11) VISUAL OPERATIONS.

NASA/MSFC

TDM 2063

ON-ORBIT SPACECRAFT ASSEMBLY/TEST

EXPERIMENT DESCRIPTION

USING A SIMULATED SPACECRAFT, MAJOR ELEMENTS OF AND ON-ORBIT SPACECRAFT ASSEMBLY AND TEST OPERATIONS ARE DEMONSTRATED. THE SPACECRAFT CORE AND ATTACHABLE MODULES ARE REMOVED FROM THE STS CARGO BAY AND TEMPORARILY STORED ON THE SPACE STATION. THE ASSEMBLY OPERATIONS THEN PROCEEDS USING A COMBINATION OF EVA, IVA AND MANIPULATORS. TEST AND VERIFICATION INCLUDING ALIGNMENT CHECKS ARE ACCOMPLISHED USING SPECIAL ASE AND GENERIC ON-BOARD CAPABILITY. THE SPACECRAFT IS ALSO FUELED. OTHER SPECIAL ASSEMBLY, TEST AND CONSTRUCTION DEMONSTRATIONS MAY ALSO BE CONDUCTED. THE SPACE STATION PROVIDES A SUITABLE WORK AREA OR PLATFORM, ENVIRONMENTAL PROTECTION, TOOLS, CONSUMABLES, ELECTRIC POWER, DATA MANAGEMENT INTERFACE AND ANALYSES SUPPORT AS REQUIRED. A LAUNCH OPERATION, I.E., RELEASE TO ORBIT USING OMV, MAY ALSO BE SIMULATED.

TDM CANDIDATE - PRECISION OPTICAL SYSTEM ASSEMBLY

OBJECTIVE:

LARGE SPACE STRUCTURES (LSS) TECHNOLOGY DEMONSTRATION:

- ON-ORBIT ASSEMBLY OF HIGH-PRECISION RIGID STRUCTURES
- DYNAMIC AND THERMAL BEHAVIOR OF STRUCTURES IN SPACE
- SUBSYSTEM INSTALLATION AND CHECKOUT
- INSTALLATION OF SEGMENTED MIRRORS
- SYSTEM IDENTIFICATION
- CONTROL OF SEGMENTED OPTICS
- DEMONSTRATION OF MAN'S ROLE AND CAPABILITIES IN SPACE

FOLLOWING ITS USE AS A LSS TDM, THIS STRUCTURE CAN BE USED AS A TESTBED FOR EXPERIMENTS RELATING TO OPTICAL AND IR TECHNOLOGY.

DESCRIPTION:

THE ON-ORBIT CONSTRUCTION OF A HIGH-PRECISION RIGID STRUCTURE IS DEMONSTRATED USING A LARGE AMBIENT IR TELESCOPE THAT IS CONSTRUCTED USING A MODULAR APPROACH TO MAXIMIZE STRUCTURAL RIGIDITY. THE PRIMARY MIRROR ASSEMBLY CONSISTS OF 7 STRUCTURAL MODULES, EACH WITH 7 HEXAGONAL MIRROR SEGMENTS. EACH STRUCTURAL MODULE IS A TETRAHEDRAL TRUSS CONSTRUCTED USING BOTH DEPLOYMENT AND ASSEMBLY TECHNIQUES. THE UPPER SURFACE IS A RIGID FRAMEWORK MANUFACTURED TO HIGH PRECISION, WITH THE 7 MIRRORS AND THEIR POSITIONING CONTROL ACTUATORS ATTACHED ON THE GROUND. THE LOWER SURFACE IS ALSO A RIGID FRAME WITH DEPLOYABLE DIAGONAL STRUTS ATTACHED. THEY ARE BOTH SIZED TO FIT WITHIN THE 4.5 METER ORBITER BAY DIAMETER FOR EFFICIENT PACKAGING. AT THE SPACE STATION, EACH MODULE IS ASSEMBLED BY, FIRST, DEPLOYING THE DIAGONAL MEMBERS FROM THE LOWER TRUSS FRAME AND THEN ATTACHING THE UPPER TRUSS FRAME (WITH MIRRORS) TO IT. THE MODULES ARE THEN ATTACHED TOGETHER TO FORM THE PRIMARY MIRROR ASSEMBLY. THE SECONDARY MIRROR AND SUPPORTS ARE THEN ATTACHED, FOLLOWED BY THE LIGHT SHIELD AND INSTRUMENTATION MODULE. ACCURACY MEASUREMENTS AND DYNAMIC TESTS ARE CONDUCTED DURING THE CONSTRUCTION TO PROVIDE STRUCTURAL PERFORMANCE INFORMATION.

FOLLOWING ITS USE AS A LSS EXPERIMENT, IT CAN SERVE AS A TESTBED FOR THE ADVANCEMENT OF OPTICAL AND IR SYSTEM TECHNOLOGIES SUCH AS THE CONTROL OF SEGMENTED OPTICS, FOCAL PLANE DEVELOPMENT, AND MAINTENANCE OF OPTICAL SYSTEMS. IT MAY ALSO BE UTILIZED AS A FUNCTIONING SENSOR SYSTEM TO PERFORM OPTICAL AND IR MEASUREMENTS WHILE ATTACHED TO THE SPACE STATION OR AS A FREE-FLYER (AFTER THE ADDITION OF THE REQUIRED PROPULSION, ATTITUDE CONTROL, GUIDANCE, DATA SYSTEMS, ETC.).

R. M. GATES

BOEING AEROSPACE COMPANY

SEATTLE, WASHINGTON

EXPERIMENT TITLE: TDM 2063 ON-ORBIT SPACECRAFT ASSEMBLY/TEST

PROPOSED FLIGHT DATE - 1993 YEAR

OPERATIONAL DAYS REQUIRED - 90

MASS - 918 KG

VOLUME:

STORED: W 4.5 x L 4.5 x H 3.4 = 70 M^3

DEPLOYED: W 4.5 x L 4.5 x H 3.4 = 70 M^3

INTERNALLY ATTACHED YES (YES/NO)
EXTERNALLY ATTACHED YES (YES/NO)
FORMATION FLYING NO (YES/NO)

ORIENTATION (inertial, solar, earth, other) N/A

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 7.2 Hrs/Day 10 No. of days

OPERATIONS: 10 Hrs/Day 10 No. of days 10 Interval

SERVICING: 6 Hrs/Day 1 No. of days 10 Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 10 Hrs/Day 10 No. of days

OPERATIONS: 10 Hrs/Day 10 No. of days 10 Interval

SERVICING: 20 Hrs/Day 1 No. of days 10 Interval

POWER REQUIRED:

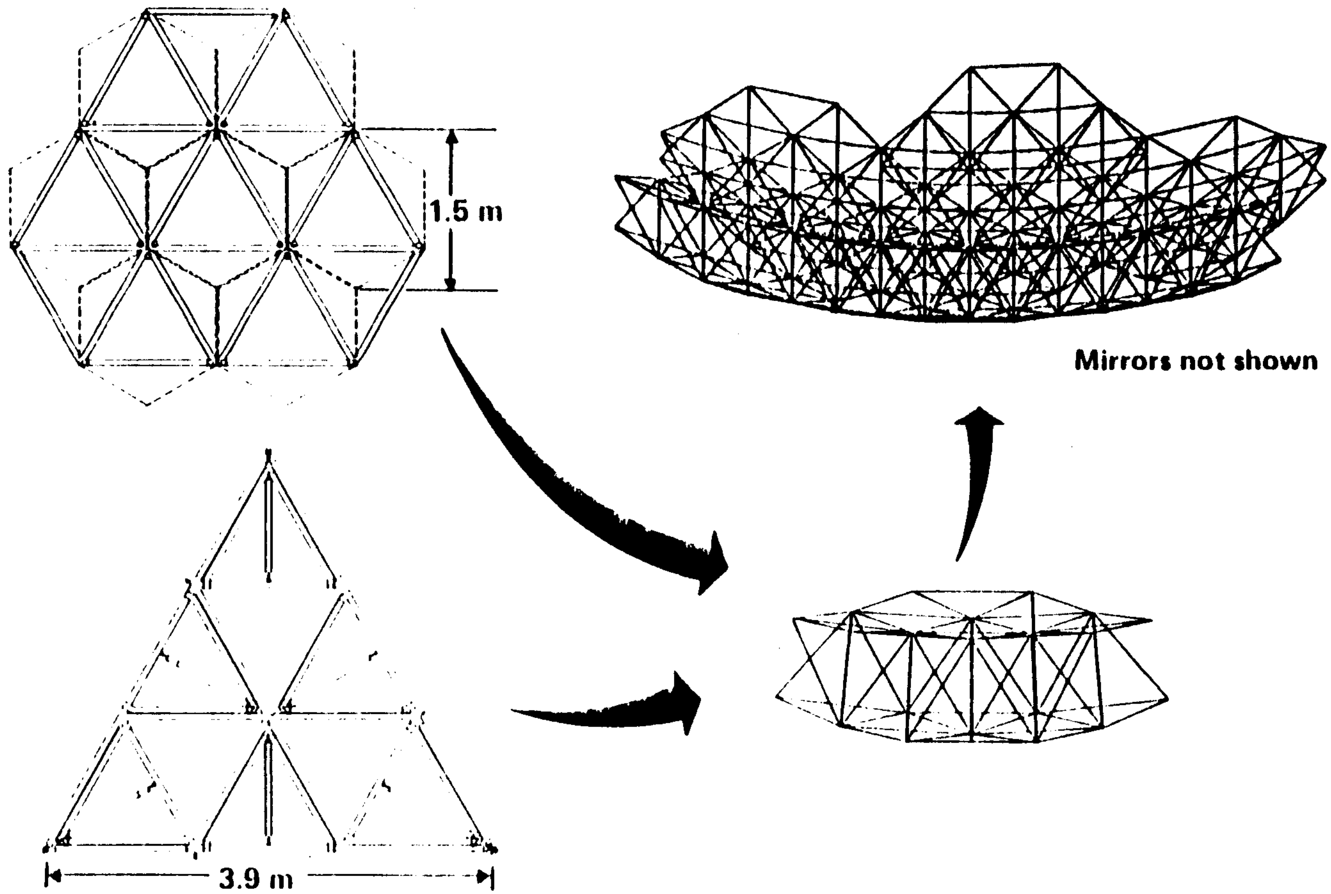
2 KW AC or DC (circle one)

23 Hrs/Day 45 No. of days

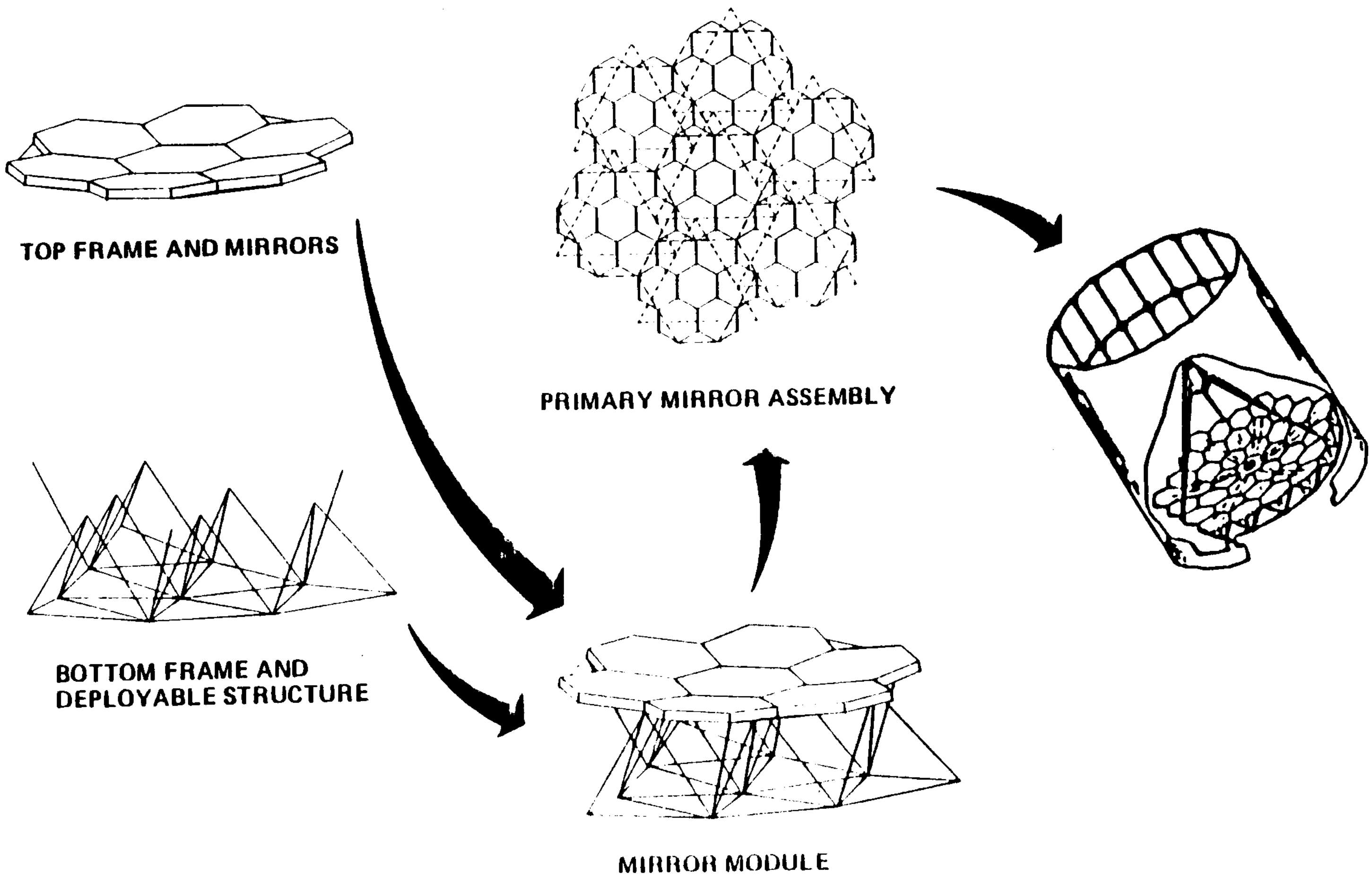
DATA RATE: 2 KBPS Megabits/second

DATA STORAGE: 8 MBPS Gigabits

Precision Optical System



Optical System Construction Scenario



EXPERIMENT TITLE: Precision Optical Spacecraft Assembly

PROPOSED FLIGHT DATE - 1994 YEAR

OPERATIONAL DAYS REQUIRED - 36

MASS - 3000 KG

VOLUME:

STORED: W 4.5 (dia.) x L 5 x H ______ = 80 M^3

DEPLOYED: W 12 (dia.) x L 14 x H ______ = 1580 M^3

INTERNALLY ATTACHED No (YES/NO)
EXTERNALLY ATTACHED Yes (YES/NO)
FORMATION FLYING No (YES/NO)

ORIENTATION (inertial, solar, earth, other) Any

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 6 Hrs/Day 30 No. of days

OPERATIONS: 6 Hrs/Day 6 No. of days 6 Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 2 Hrs/Day 30 No. of days

OPERATIONS: 6 Hrs/Day 6 No. of days 6 Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

POWER REQUIRED:

1 KW AC or DC (circle one)

6 Hrs/Day 36 No. of days

DATA RATE: 1 Megabits/second

DATA STORAGE: 0.2 Gigabits

NASA/MSFC

TDM 2066

INFLATABLE/RIGIDIZABLE STRUCTURAL ELEMENT

EXPERIMENT OBJECTIVE

TO UTILIZE INFLATABLE/RIGIDIFIABLE STRUCTURES FOR APPLICABLE SPACE STATION FUNCTIONS. THESE FUNCTIONS INCLUDE AIRLOCKS, UNPRESSURIZED HANGARS, DOCKING FACILITIES AND OTHER APPLICATIONS TO BE DEFINED. IT IS BELIEVED THAT INFLATABLE/REGIDIFIABLE STRUCTURES CAN BE OF SIGNIFICANT BENEFIT IN "SATELLITE SERVICING" OPERATIONS AT SPACE STATION, PARTICULARLY SPECIAL ONE TIME SERVICING OPERATIONS.

INFLATABLE/RIGIDIZABLE STRUCTURAL ELEMENT

EXPERIMENT DESCRIPTION

THE SYSTEM WOULD BE SIZED TO ACCOMODATE LARGE SPACECRAFT (COMPLETE WITH ORBITER DIMENSIONS) OFFERING BERTHING AND DOCKING PROVISIONS. ORBITER COMPATIBLE MOUNTING SYSTEMS, AND A POSITIONING SYSTEM TO PROVIDE VEHICLE MOVEMENT. MOVABLE TRACK-MOUNTED WORK STATIONS ARE REQUIRED TO PROVIDE OPTIMUM ACCESS FOR THE ASTRONAUT TO SERVICED ITEMS AND AREAS. MICROMETEOROID/DEBRIS AND RADIATION WILL BE PROVIDED ALONG WITH THERMAL CONTROL OF THE SERVICE HANGAR. THE SYSTEM WILL BE TOTALLY ENCLOSED WITH DOOR DESIGNED TO ALLOW MAXIMUM ACCESS. INGRESS/EGRESS MAY BE PROVIDED AT BOTH ENDS. LIGHTING, POWER, AND TOOL STATIONS WILL BE LOCATED AT STRATEGIC POSITIONS IN THE HANGAR.

EXPERIMENT TITLE: TDM 2066 INFLATABLE/RIGIDIZED STRUCTURAL ELEMENT

PROPOSED FLIGHT DATE - 1995 YEAR

OPERATIONAL DAYS REQUIRED - 120

MASS - 1900 KG

VOLUME:

STORED: W 5.0 x L 1.6 x H 1.6 = 12.8 M^3

DEPLOYED: W 5.0 x L 11.0 x H 5.0 = 275 M^3

INTERNALLY ATTACHED NO (YES/NO)
EXTERNALLY ATTACHED YES (YES/NO)
FORMATION FLYING NO (YES/NO)

ORIENTATION (inertial, solar, earth, other) ALL

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 10 Hrs/Day 10 No. of days

OPERATIONS: 8 Hrs/Day 10 No. of days 10 Interval

SERVICING: 6 Hrs/Day 1 No. of days 10 Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 10 Hrs/Day 10 No. of days

OPERATIONS: 10 Hrs/Day 10 No. of days 10 Interval

SERVICING: 6 Hrs/Day 1 No. of days 10 Interval

POWER REQUIRED:

2 KW AC or DC (circle one)

10 Hrs/Day 60 No. of days

DATA RATE: 2 KBPS Megabits/second

DATA STORAGE: 8 KBPS Gigabits

IN-SPACE ACTIVELY CONTROLLED STRUCTURE

OBJECTIVE

TO DEMONSTRATE BY MEANS OF A 1/2 SCALE MODEL :

* THE ABILITY TO MEASURE & CONTROL ALIGNMENTS
* THE ABILITY TO SENSE & ATTENUATE DYNAMICS
* PRECISION POINTING OF A LIGHTWEIGHT PLATFORM

DESCRIPTION

* A GEODESIC PLATFORM,OF TUBULAR ELEMENTS, DESIGNED FOR CONTROLABILITY
* SOLID STATE LASER-BASED ALIGNMENT SYSTEM FOR HIGH BANDWIDTH MULTIMODE MEASUREMENT
* PIEZOELECTRIC & ELECTROMAGNETIC ACTUATORS INTEGRATED INTO THE STRUCTURE
* A VARIABLE FREQUENCY DISTURBANCE SOURCE
* INSTRUMENTED DUMMY(OR REAL)LOADS AT REPRESENTATIVE INSTRUMENT LOCATIONS

P. Stiller
GSFC 716

IN-SPACE ACTIVELY CONTROLLED STRUCTURE

RATIONALE

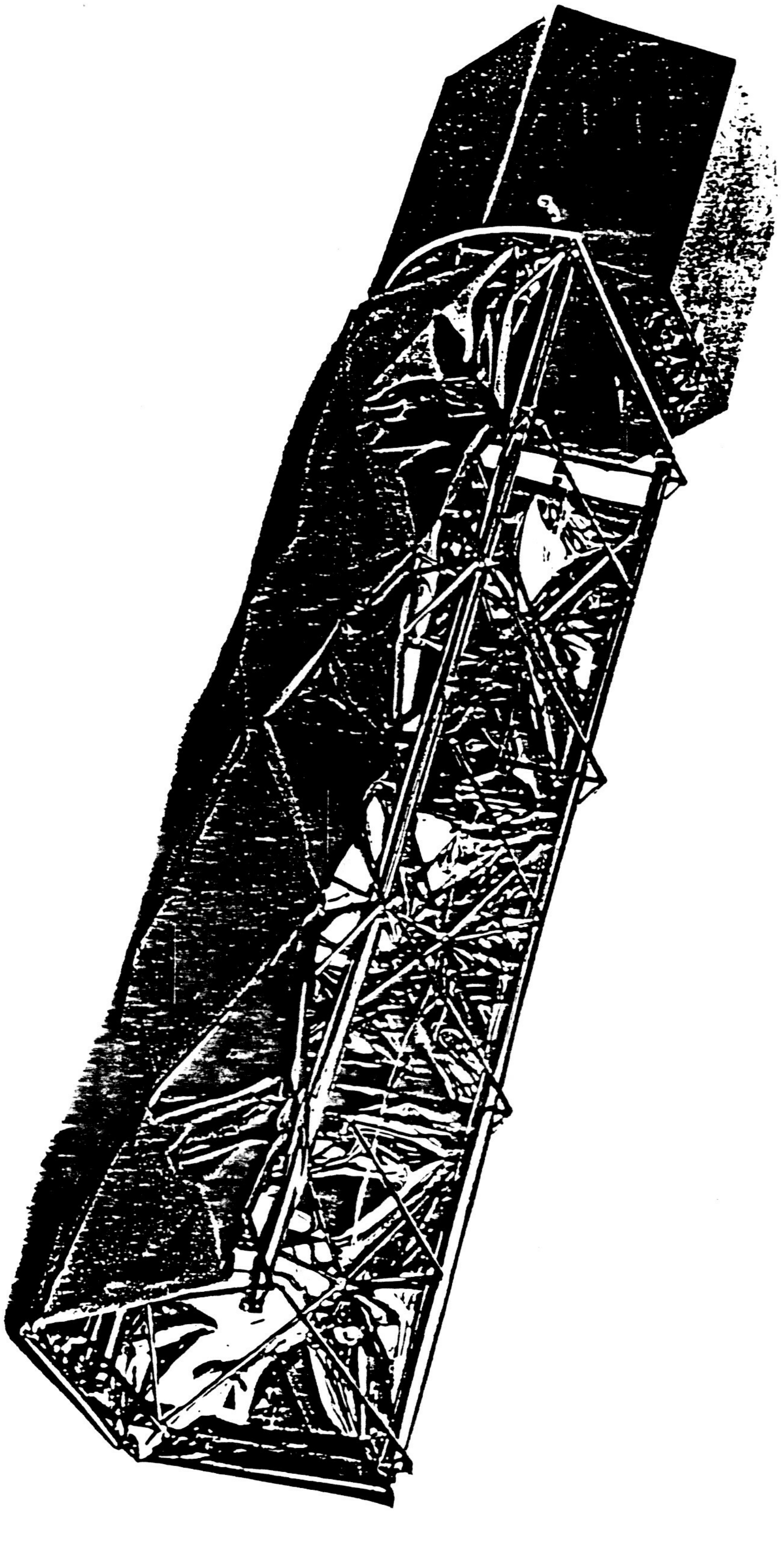
* MULTIPLE PAYLOAD PLATFORMS HAVE MANY SHARP RESONANCES ABOVE THE ATTITUDE CONTROL BW., WHICH AFFECT THE LINE OF SIGHT.
* ACTIVE CONTROL CAN CORRECT DISTORTION AND PREVENT AMPLIFICATION OF DISTURBANCES FROM OTHER INSTRUMENTS & SPACECRAFT APPENDAGES.

ALTERNATIVES

PASSIVE DAMPING AND RAISEING ATTITUDE CONTROL BANDWIDTH APPEAR TO BE INADEQUATE TO COVER THE 0.1HZ.TO 100HZ. RANGE.

* MULTILEVEL CONTROL,IMAGE MOTION COMPENSATION AND GROUND DEJITTERING OF TRANSMITTED DATA ARE NOT GENERIC & MORE EXPENSIVE TO EACH EXPERIMENTER.
* MANY"MICRO g"EXPERIMENTS WILL ALSO REQUIRE SIMILIAR TECHNIQUES.

P. Studer
GSFC 716



EXPERIMENT TITLE: IN-SPACE ACTIVELY CONTROLLED STRUCTURE

PROPOSED FLIGHT DATE - 1989 YEAR

OPERATIONAL DAYS REQUIRED - ONE

MASS - 300 KG

VOLUME:

STORED: W 2.2 x L 8.5 x H 2.2 = 41 M^3

DEPLOYED: W ______ x L ______ x H ______ = ______ M^3

INTERNALLY ATTACHED N (YES/NO)
EXTERNALLY ATTACHED Y (YES/NO)
FORMATION FLYING N (YES/NO)

ORIENTATION (inertial, solar, earth, other) SOLAR

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 0 Hrs/Day ______ No. of days

OPERATIONS: 2 Hrs/Day 2 No. of days ______ Interval

SERVICING: 0 Hrs/Day ______ No. of days ______ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 0 Hrs/Day ______ No. of days

OPERATIONS: 0 Hrs/Day ______ No. of days ______ Interval

SERVICING: 0 Hrs/Day ______ No. of days ______ Interval

POWER REQUIRED:

0.1 KW AC or DC (circle one)

1 Hrs/Day 2 No. of days

DATA RATE: 0.2 Megabits/second

DATA STORAGE: 0.7 Gigabits

P. STUDER

IN-SPACE ACTIVELY CONTROLLED STRUCTURE

OBJECTIVE

To demonstrate by means of a 1/2 scale model, the ability to measure and correct alignment errors, attenuate structrual dynamic disturbances, and prove a precison pointing capability for a lightweight platform in the space environment.

DESCRIPTION

- A geodesic tubular truss with controllable tensile elements.
- A laser based optical alignment system for real-time measurement.
- A variable frequency disturbance source.
- Instrumented dummy loads at representative instrument locations.

This structure, designed with active control will provide readily scaleable results on the pointing precision and stability of free-flying platform for Earth Observing Systems. Pre and post flight simulations and tests will be enhanced by actual data on solar thermal exposure and the control dynamics in zero "g." These results will be useful in the development of experiments for micro "g" manufacturing as well as lightweight structures for high resolution science and imaging applications.

Advanced structural design concepts are being developed to reduce the present structural weight (increase payloand fraction) while expanding the state-of-the-art in coalignment and dynamic control above the bandwidth of the attitude control system. Lightweight low power actuators using newly developed polymeric thin film piezoelectrics may be flown for the first time. Integration of actuators into structure without compromising structural integrity is one of the challenges. The entire dynamic range encompases six orders of magnitude, (2.5 cm to .025 micrometers) displacements (1 "g" to 1 micro "g") accelerations, and frequencies from a fraction of a Hz to 100 Hz. Electromagnetic devices, capable of generating velocity dependent outputs for damping purposes and handling the longer stroke range will also be employed. Controlled impulse and swept frequency generators will be employed to provide a comprehensive data set for later analysis. Analysis techniques already developed for flight data on the Landsat program can be applied to assess the performance effectiveness of the structure, specific actuators, and the distributed control system.

P. STUDER

SPACE STATION STRAIN AND ACOUSTICS SENSORS

A Measurement Science Program To Insure Space Station Reliability And Provide Quantitative Real Time Information For Dynamic Configuration Monitoring

PROGRAM OBJECTIVE:

- Maintain space Station Surveillance For Structural Health By Monitoring Acoustic Emission At Critical Joints And Providing Impact Damage Assessment Sensor

PROGRAM APPROACH:

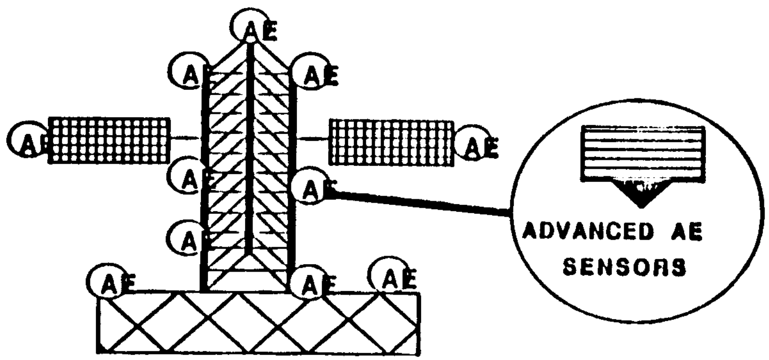
- Develop Measurement Technology For Space Station To Provide Accurate, Strain Information For Configuration / Operation Feedback
- Integrate Acoustic Emission Sensors Into Space Station To Monitor Critical Joints, Structural Elements, Pressure Systems, Operation Hardware
- Develop A Space Station " Nervous System " With Advanced Microcomputers To Acquire NDE, Strain, Configuration, Vibration Data
- Develop Analysis Technology To Provide Real Time Operation Information From The NDE Data Bases

Joseph Heyman LaRC X3036

SPACE STATION STRAIN AND ACOUSTICS SENSORS

ACOUSTIC EMISSION PROGRAM:

- Select Commercially Available AE Sensors And Evaluate Performance On Space Station Geometries / Materials / Joints / Pressure Systems
- Develop Discrete AE Sensors To Achieve Performance Requirements Using Available Technology And Developing Necessary New Technology
- Develop Electronics System For AE Monitoring / Analysis
- Develop In Situ AE Sensor Technology For Integration Into Advanced Space Station Concepts
- Integrate AE Sensors Into Composites For Advanced Materials For SS

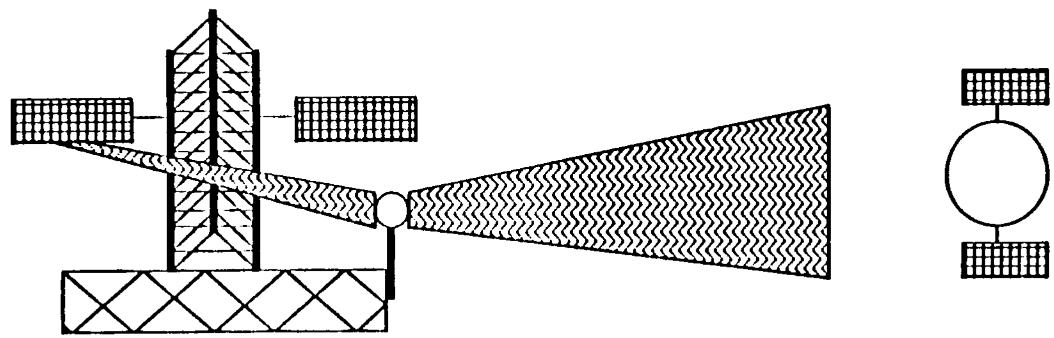


Joseph Heyman LaRC X3036

SPACE STATION STRAIN AND ACOUSTICS SENSORS

REMOTE STRAIN SENSOR PROGRAM:

- Develop Phase Locked Loop Optical System For Strain Sensing
- Develop High Frequency Electronics System For Above
- Investigate Discrete High Speed Diode Distributed Sources For SS Application
- Investigate Fiber Optics Source For Clustered Sensors
- Develop System To Monitor Specific Key Structural Elements
- Develop System To Remotely Monitor Distance To Any Structural Element Within Field Of View
- Working In Concert With Structures / Space Directorate - Develop Finite Element Approach To Analyze Remote NDE Data For Full Structural Performance



Joseph Heyman LaRC X3036

EXPERIMENT TITLE: SPACECRAFT STRAIN AND ACOUSTIC SENSORS

PROPOSED FLIGHT DATE - 1992 **YEAR**

OPERATIONAL DAYS REQUIRED - 365

MASS - 25 **KG**

VOLUME: 0.125 M^3

STORED	**W**	0.5	**x L**	0.5	**x H**	0.5	**=**	0.125	M^3
DEPLOYED	**W**	0.5	**x L**	0.5	**x H**	0.5	**=**	0.125	M^3

INTERNALLY ATTACHED YES **(YES/NO)**
EXTERNALLY ATTACHED YES **(YES/NO)** SENSORS
FORMATION FLYING ______ **(YES/NO)**

ORIENTATION (inertial, solar, earth, other) ANY

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	6MHR	**Hrs/Day**	1	**No. of days**		
OPERATIONS:		**Hrs/Day**		**No. of days**		**Interval**
SERVICING		**Hrs/Day**		**No. of days**		**Interval**

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP:	1MHR	**Hrs/Day**	1	**No. of days**		
OPERATIONS:		**Hrs/Day**		**No. of days**		**Interval**
SERVICING		**Hrs/Day**		**No. of days**		**Interval**

POWER REQUIRED:

0.3 **KW** **AC or DC (circle one)**

23 **Hrs/Day** 365 **No. of days**

DATA RATE: 0.1 **Megabits/second**

DATA STORAGE: 0.1 **Gigabits**

Joe Heyman-LaRC-3036

THERMAL SHAPE CONTROL

HOWARD M. ADELMAN
NASA LANGLEY RESEARCH CENTER

EXPERIMENT OBJECTIVE

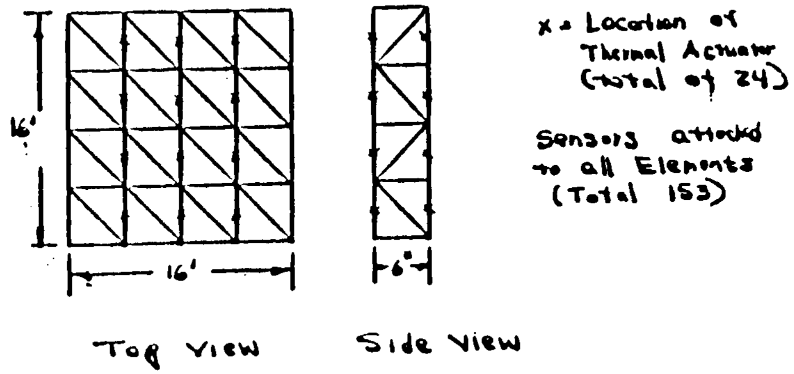
TO DETERMINE THE FEASIBILITY OF CONTROLLING SHAPE DISTORTION OF FLEXIBLE SPACE STRUCTURES (E.G., ANTENNAE) BY ONBOARD HEATING IN WHICH DISTRIBUTED THERMAL CONTROLLERS MINIMIZE SENSED DISTORTIONS IN THE SHAPE OF FLEXIBLE SPACE STRUCTURES DURING LONG ORBITAL FLIGHTS.

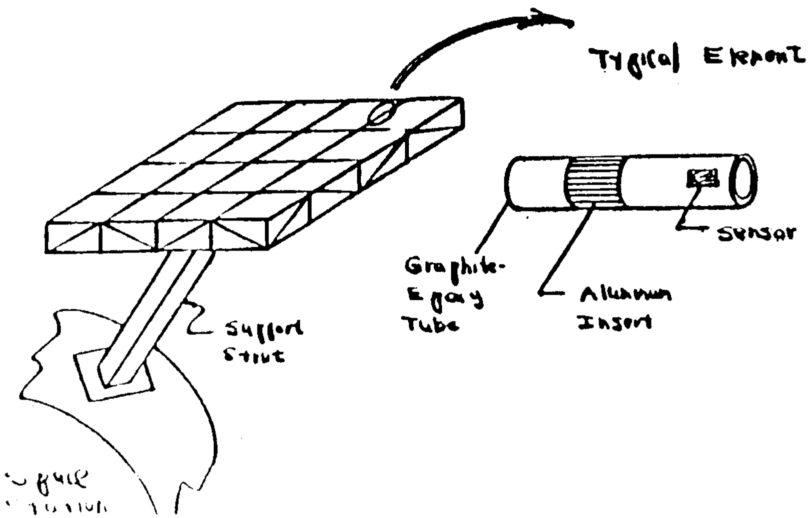
EXPERIMENT DESCRIPTION

A LARGE, FLEXIBLE PANEL WILL BE ATTACHED BY A STRUT TO THE SPACE STATION. THERMAL ACTUATORS (HEATERS) WILL BE DISTRIBUTED THROUGHOUT THE PANEL AT SPECIFIED LOCATIONS. A SUITE OF SENSORS ALSO DISTRIBUTED THROUGHOUT THE PANEL WILL SENSE DEVIATIONS FROM THE REQUIRED SHAPE. THE HARDWARE WILL CONSIST OF A 16′ BY 16′ BY 6″ PLANAR TRUSS STRUCTURE WITH 24 THERMAL ACTUATORS AND 153 SENSORS. THE SENSORS SHOULD BE CAPABLE OF MEASURING DEFLECTIONS NORMAL TO THE SURFACE OF ABOUT 1.0 MM. AS SOON AS FEASIBLE AFTER THE SPACE STATION IS OPERATIONAL, THE PANEL WILL BE FLOWN TO THE STATION AND ATTACHED TO IT. THE EXPERIMENT WILL REQUIRE A COMPUTER WHICH CAN EITHER BE THE STATION'S OR A DEDICATED MICROPROCESSOR. IN EITHER CASE, THERE WILL BE A NEED FOR DATA ACQUISITION (FROM THE SENSOR OUTPUTS) AND DATA DELIVERY (TO THE THERMAL ACTUATORS).

THE OUTPUT OF THE SUITE OF SENSORS WILL BE USED IN THE COMPUTER IN CONJUNCTION WITH A DESCRIPTION OF THE STRUCTURE CALCULATED A PRIORI TO GENERATE COMMAND TEMPERATURES FOR THE THERMAL ACTUATORS. THE RESPONSE OF THE HEATERS TO THE COMMANDS WILL CREATE A TEMPERATURE DISTRIBUTION IN THE PANEL WHICH WILL TEND TO OFFSET THE SHAPE DISTORTIONS. THE COMPUTATIONAL REQUIREMENTS FOR THIS TDM EXPERIMENT ARE MODEST. THE CONTROL LOOP SIMPLY REQUIRES ONE MATRIX INVERSION AND TWO MATRIX MULTIPLICATIONS PER ITERATION.

TEST ARTICLE FOR THERMAL SHAPE CONTROL





Thermal Shape Control
H.M. Adelman

EXPERIMENT TITLE: THERMAL SHAPE CONTROL

PROPOSED FLIGHT DATE - 1992 YEAR

OPERATIONAL DAYS REQUIRED - 30

MASS - 120 KG

VOLUME:

STORED: W 4.88 x L 4.88 x H .152 = 3.62 M^3

DEPLOYED: W 4.88 x L 4.88 x H .152 = 3.62 M^3

INTERNALLY ATTACHED No (YES/NO)
EXTERNALLY ATTACHED YES (YES/NO)
FORMATION FLYING No (YES/NO)

ORIENTATION (inertial, solar, earth, other) EARTH

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 2 Hrs/Day 1 No. of days

OPERATIONS: 1 Hrs/Day 5 No. of days 6 Interval

SERVICING: 0.5 Hrs/Day 2 No. of days 15 Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 2 Hrs/Day 1 No. of days

OPERATIONS: 1 Hrs/Day 5 No. of days 6 Interval

SERVICING: 0 Hrs/Day 0 No. of days 0 Interval

POWER REQUIRED:

0.25 KW AC or DC (circle one)

1 Hrs/Day 5 No. of days

DATA RATE: TBD Megabits/second

DATA STORAGE: TBD Gigabits

TDMX 2431 - ADVANCED CONTROL DEVICE TECHNOLOGY

Experimenter: N. J. Groom

OBJECTIVE

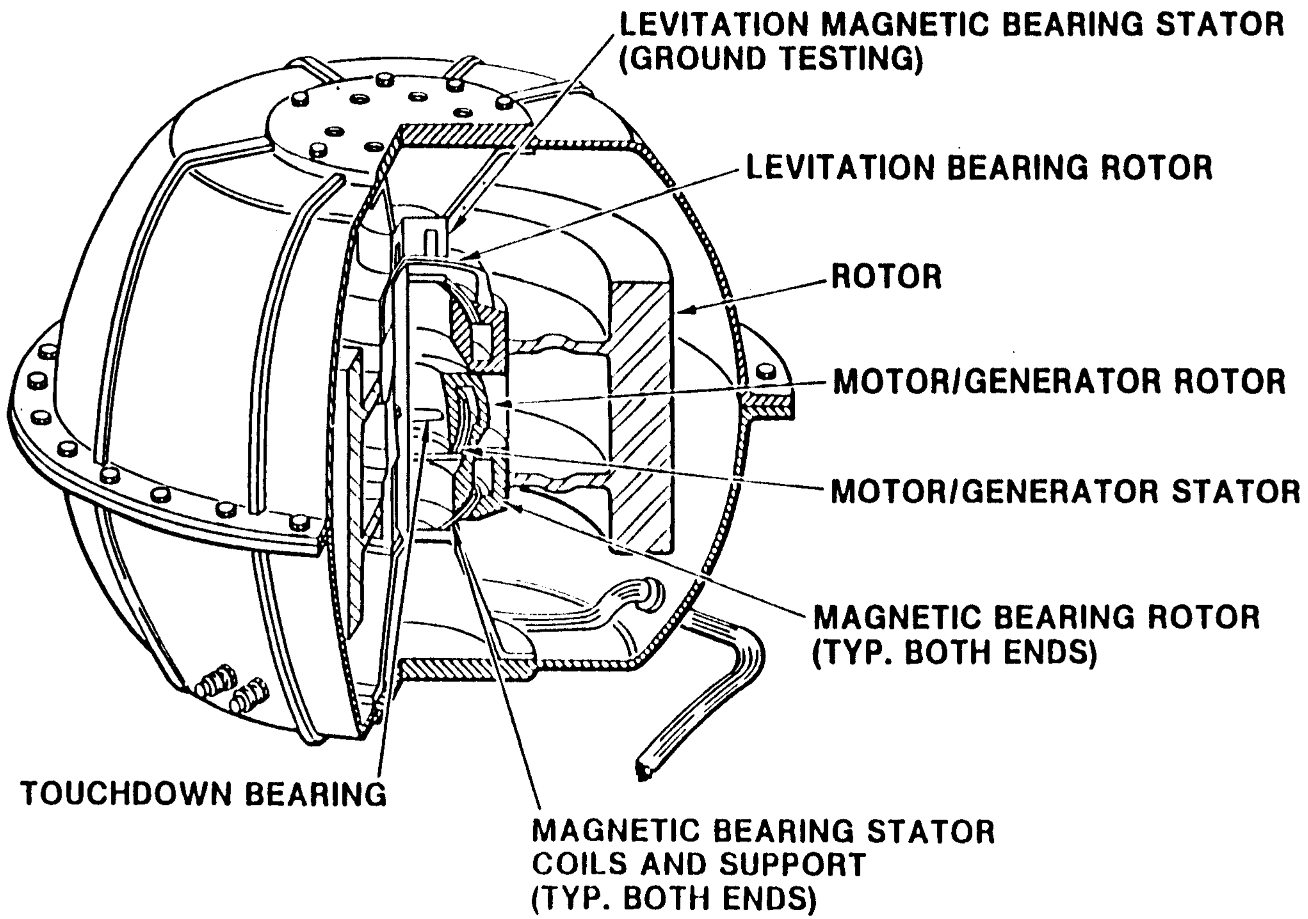
- EVALUATE THE FEASIBILITY/PERFORMANCE OF A COMBINED ATTITUDE CONTROL AND ENERGY STORAGE SYSTEM UTILIZING ANNULAR MOMENTUM CONTROL DEVICE (AMCD) TECHNOLOGY. THIS TECHNOLOGY INCLUDES: MAGNETIC SUSPENSION, COMPOSITE ROTORS, ELECTRICAL/ROTATIONAL ENERGY CONVERSION, AND CONTROL LAWS.

DESCRIPTION

- CANDIDATE AMCD COMBINED CONTROL AND ENERGY STORAGE SYSTEM WILL BE SELECTED BASED ON RESULTS OF ON-GOING STUDIES.
- EXTENSIVE GROUND-BASED TESTING OF CRITICAL ELEMENTS OF SELECTED SYSTEM WILL BE PERFORMED.
- FLIGHT EXPERIMENT WILL BE DEFINED TO VALIDATE GROUND-BASED EXPERIMENTAL DATA AND ANALYTICAL STUDIES AND TO DEMONSTRATE FEASIBILITY AND EFFECTIVENESS OF AMCD TECHNOLOGY IN AN OPERATIONAL ENVIRONMENT.

TDMX 2431 — ADVANCED CONTROL DEVICE TECHNOLOGY

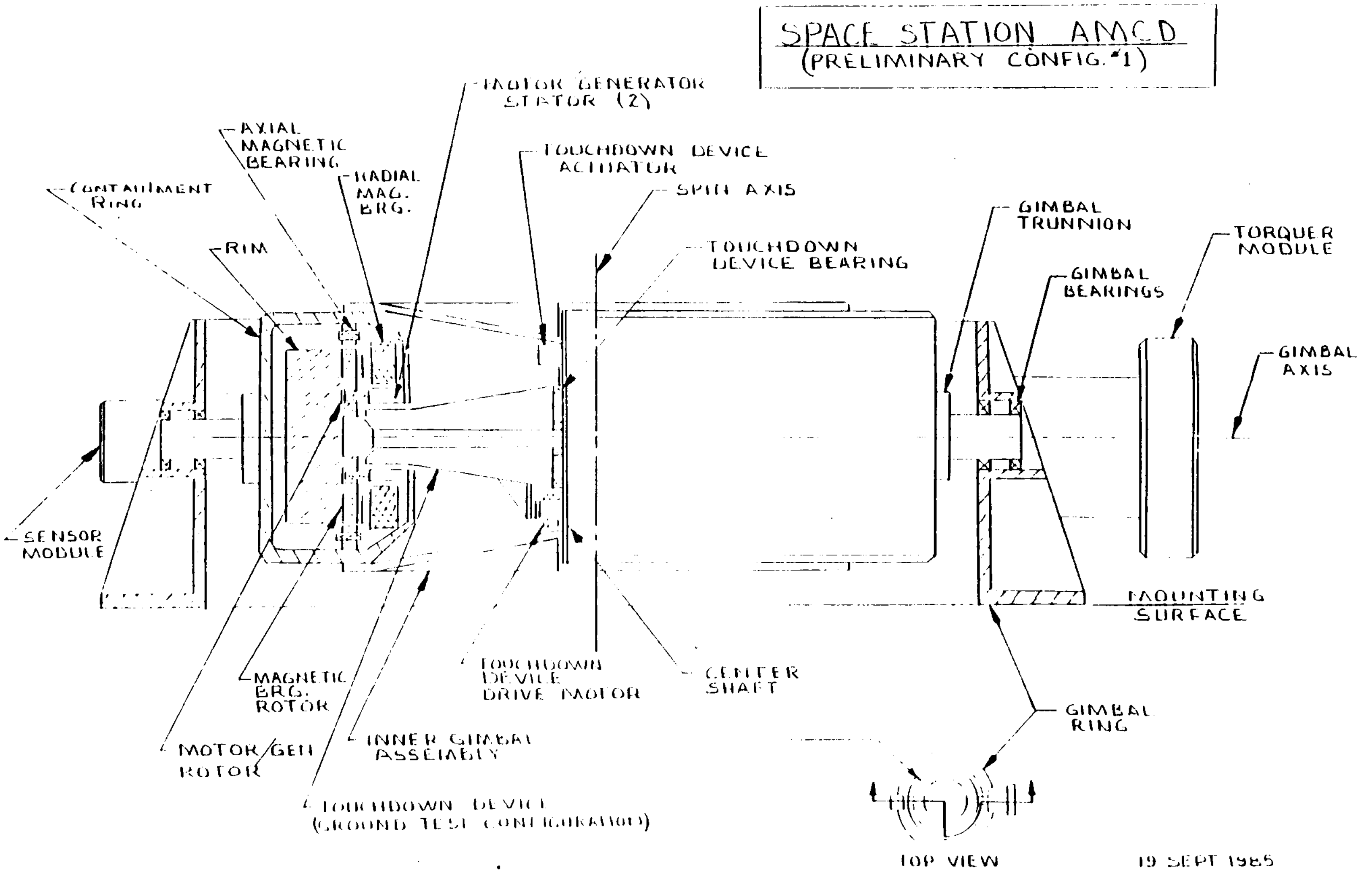
Experimenter: N. J. Groom



CANDIDATE AMCD COMBINED CONTROL AND ENERGY STORAGE SYSTEM (ACCESS) UNIT DESIGN CONCEPT

TDMX 2431 — ADVANCED CONTROL DEVICE TECHNOLOGY

Experimenter: N. J. Groom



CANDIDATE AMCD COMBINED CONTROL AND ENERGY STORAGE SYSTEM (ACCESS) UNIT DESIGN CONCEPT

TDMX 2431 — ADVANCED CONTROL DEVICE TECHNOLOGY

Experimenter: N. J. Groom

EXPERIMENT TITLE: ADVANCED CONTROL DEVICE TECHNOLOGY

PROPOSED FLIGHT DATE - 1994 YEAR

OPERATIONAL DAYS REQUIRED - 365

MASS - 3600 KG

VOLUME:

STORED: W 1.2 x L 3.0 x H ______ = 3.4 M^3

DEPLOYED: W 1.2 x L 3.0 x H ______ = 3.4 M^3

INTERNALLY ATTACHED No (YES/NO)
EXTERNALLY ATTACHED Yes (YES/NO)
FORMATION FLYING No (YES/NO)

ORIENTATION (inertial, solar, earth, other) N/A

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 12 Hrs/Day 1 No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ______ Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 9.0 Hrs/Day 1 No. of days

OPERATIONS: 1.11 Hrs/Day 52 No. of days 7 Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

POWER REQUIRED:

1.5 KW AC or DC (circle one)

23.0 Hrs/Day 300 No. of days

DATA RATE: 0.05 Megabits/second

DATA STORAGE: 0.192 Gigabits

Experiment Title: Ion Beam Cold Welding, TDMX 2065

Proposer: Bernard L. Sater
NASA, Lewis Research Center
(216) 433-5291

Experiment Objective:

Experiment objective is to demonstrate ion beam cold welding as a method that is ideal for fabrication of large space structures. Space structures are characterized as pressure vessels for fluid storage and living conditions and as open frame structures for large antennas and external platforms. At present, the Shuttle bay volume limits the diameter and length of space structural members. Future fabrication, repair and modification of large structures will require reliable and efficient methods of welding metal materials. Conventional welding methods have major drawbacks which are avoided with the ion beam cold welding technology.

Experiment Description:

In theory, if two perfectly clean metal surfaces are forced into intimate contact a solid-state metallic bond is produced at the interface. The normal interatomic forces of attraction which hold the atoms of the parent metal will also hold the atoms in the bond made between the separate pieces. Such bonds could be as strong as those in parent metal providing ideal mechanical and metallurgical conditions are made.

In reality, metal surfaces are not atomically "clean" but contaminated. The effectiveness of an oxide layer to prevent metal-to-metal bonds exists down to one or two monolayers of coverage. All effective welding processes must disrupt surface films and establish metal-to-metal intimacy.

With the ion beam cold welding method, an inert gas ion beam has proven to be very effective in removing the surface contamination layers by sputtering, thus exposing clean underlying metal which can be readily welded with minimal pressure to assure intimate contact. High quality ion beam cold welding of a variety of metals without measurable deformation has been demonstrated, eliminating many of the problems associated with conventional welding processes.

The experiment proposed is intended to demonstrate a method of welding which may have several Space Station applications. What may be the best experiment to propose will require study. Figures 1 and 2 are artist's conceptions of two different applications for examples. In Figure 1, aluminum strip is roll-formed into an intricate shape such as a pipe with the seam ion beam cold welded. Other shapes may be more desirable for space beams. Figure 2 shows hand held ion beam cold welding tools being used to assemble girders. Perhaps tools like these could repair leaks in living quarters or to make modifications to structures. The ion beam cold welding experiment should represent tooling for a particular application selected after study and consideration.

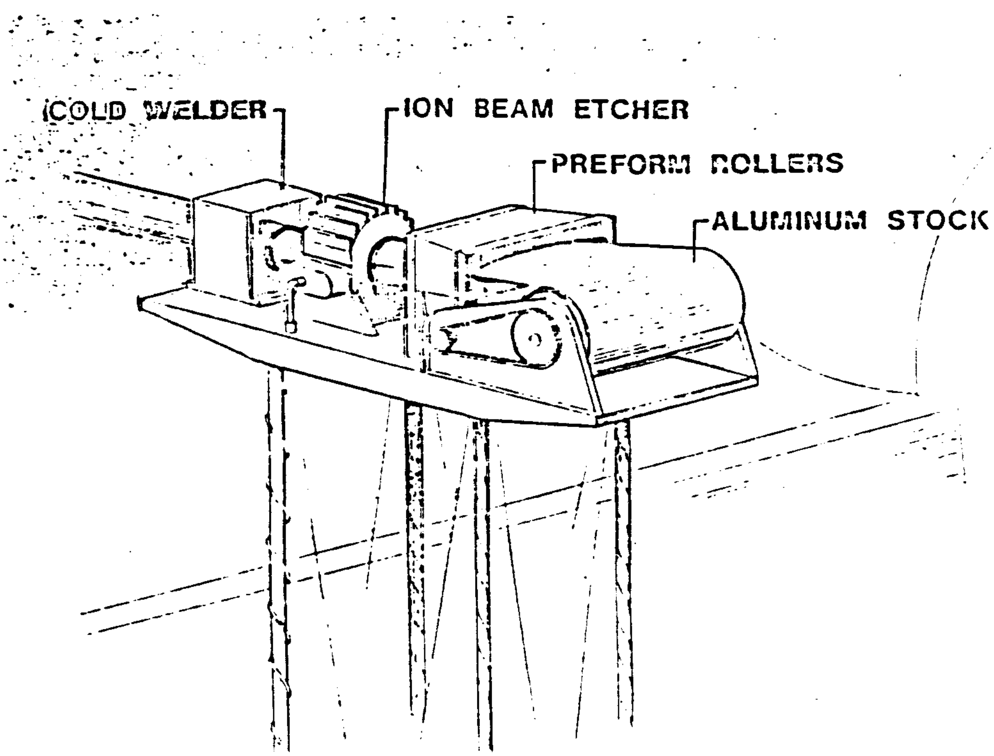


FIGURE 1

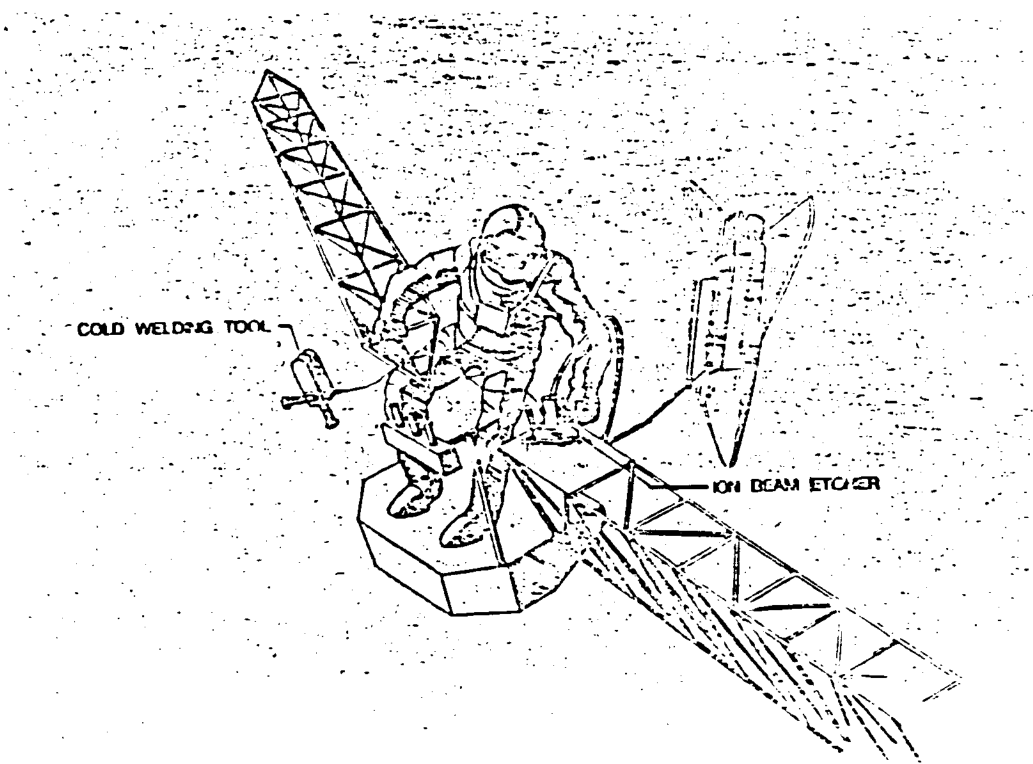


FIGURE 2

EXPERIMENT TITLE: Ion Beam Cold Welding
(Experiment will depend upon a particular application selected after study and consideration)

PROPOSED FLIGHT DATE - ____________ YEAR

OPERATIONAL DAYS REQUIRED - ____________

MASS - ____________ KG

VOLUME:

STORED: W ______ x L ______ x H ______ = ______ M^3

DEPLOYED: W ______ x L ______ x H ______ = ______ M^3

INTERNALLY ATTACHED ______ (YES/NO)
EXTERNALLY ATTACHED ______ (YES/NO)
FORMATION FLYING ______ (YES/NO)

ORIENTATION (inertial, solar, earth, other) ____________

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ______ Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ______ Interval

SERVICING: ______ Hrs/Day ______ No. of days ______ Interval

POWER REQUIRED:

$<$ 1.0 KW AC or DC (circle one)

______ Hrs/Day ______ No. of days

DATA RATE: None Megabits/second

DATA STORAGE: None Gigabits

LARGE DEPLOYABLE REFLECTOR SPACE STATION IMPACT

- o SPACE STATION PROVIDES:
  - STORAGE
  - ASSEMBLY/DEPLOYMENT FUNCTIONS
  - INITIAL CHECKOUT CAPABILITY
  - REFURBISH CAPABILITY
    - NEW FOCAL PLAN INSTRUMENTS
    - CRYOGENIC REFIL
- o LDR CHARACTERISTICS
  - 30,000 KG TOTAL WEIGHT
  - LARGE MOMENT OF INERTIA

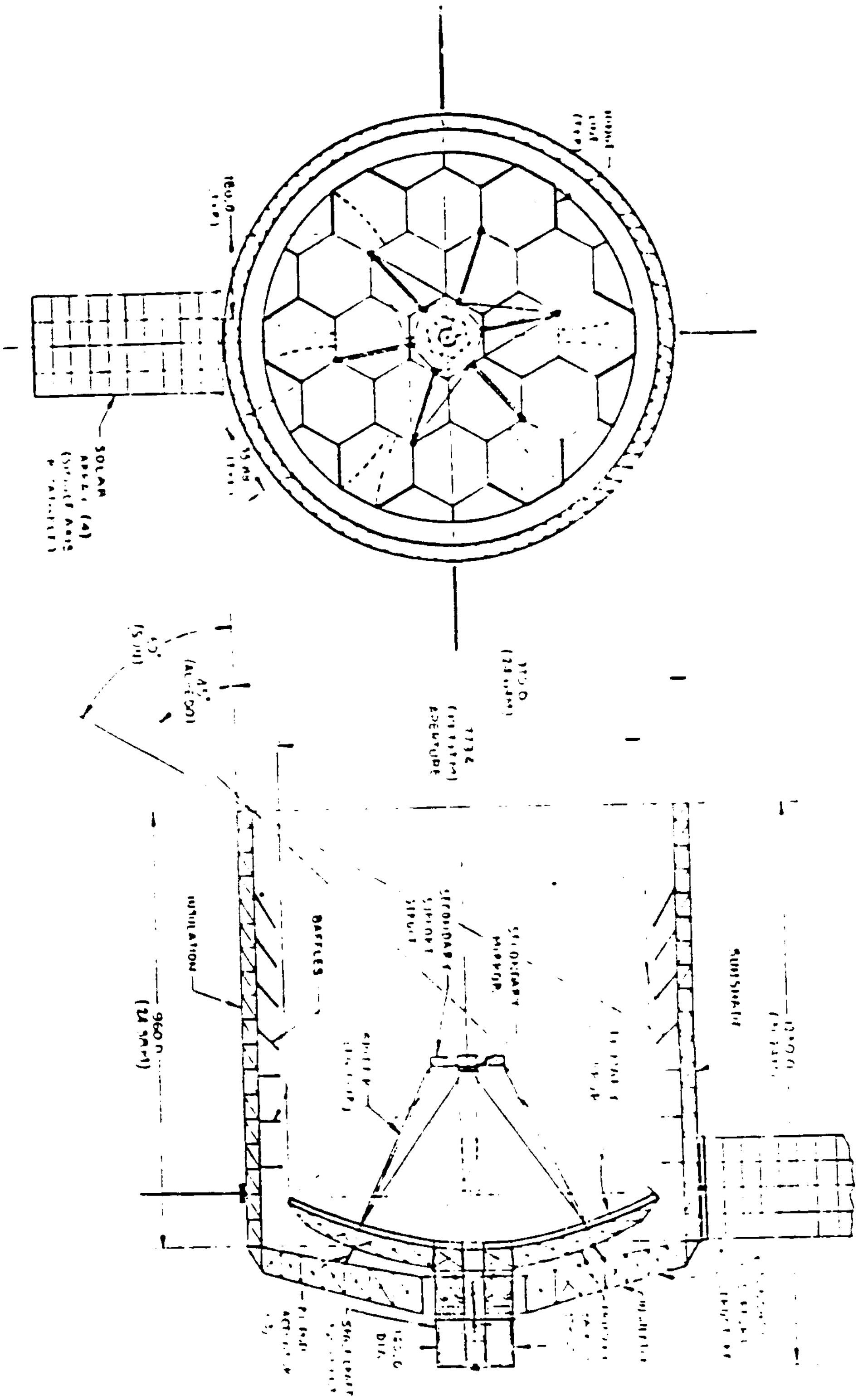
Experiment Objective

The Large Deployable Reflector (LDR) is a NASA concept of a very large, earth orbiting, far-infrared to sub-millimeter (diffraction limited performance at 30-50 μm) astronomical telescope to be launched in the late 1990s and to utilize the space station. LDR will conduct investigations of a wide variety of astrophysical phenomena throughout the far-infrared spectrum. Systems studies carried out since 1979 indicate that, given accelerated technology development in certain areas, it is feasible to build, deploy and maintain for a mimimum lifetime of 10 years an LDR having a 20-m diameter, segmented, primary mirror and containing 4-8 science science instruments operating between $\lesssim 1$ K and 20 K. Although a free-flyer in a 28.5^0, 700-800 km orbit, LDR is transported in sections to the space station, assembled and checked out at space station prior to orbit transfer. Furthermore, LDR is serviced (involving mainly replenishment of cryogens and propellants) at regular intervals (≈2 years), at or from space station.

Experiment Description

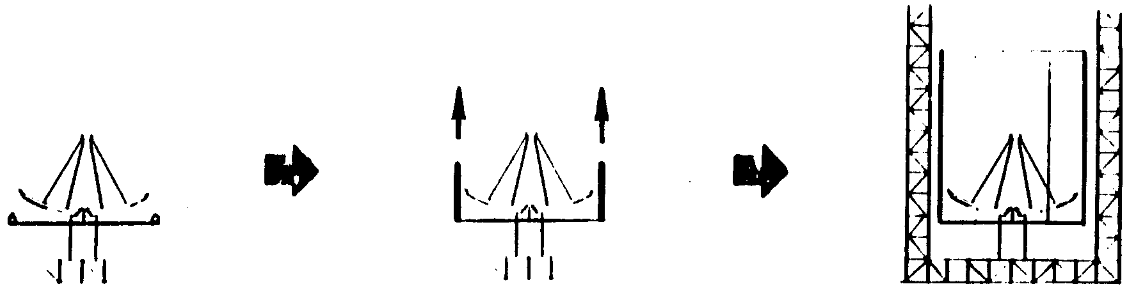
LDR will be a free-flyer but utilize space station for storing system components and subsections brought to the station in two or more shuttle loads. Because of LDR's large size (20-m primary mirror, 20x20 m sunshade) and weight (approx. 30,000 kg fully furbished) the requirements of storage and assembly space, for checkout after assembly, for storage and transfer of replenishments and for replacement parts during servicing of LDR, may significantly impact space station facilities design. These issues are being addressed in current, NASA-Ames sponsored, studies independently by Eastman Kodak and Lockheed.

It is anticipated that the various LDR activities on space station will involve IVA and EVA and mobile RMS, teleoperator and, perhaps, robot activities. The balance of these activities depends on future progress made in these areas (e.g. in the 8 psi, quick-donning space suit), cost and risk. Electrical power, data and communication requirements of LDR are presently believed not to place excessive demands on space station. However, the impact of LDR on the dynamic and thermal control system of space station and the minimization of contamination of LDR optics by molecules and particulates at space station may be critical issues. Space station concepts (basic geometry, mass, accomodation capability) are now in rapid development, and the magnitude of these effects is therfore not known. LDR has stringent pointing and thermal control requirements. The possibility of tethering LDR during checkout at space station to minimize LDR-space station dynamical and thermal interactions (as well as contamination) is being considered. The impact of LDR on other experiments ongoing at space station during LDR assembly, checkout and refurbishing is also being studied.



LDR ASSEMBLY (CONT)

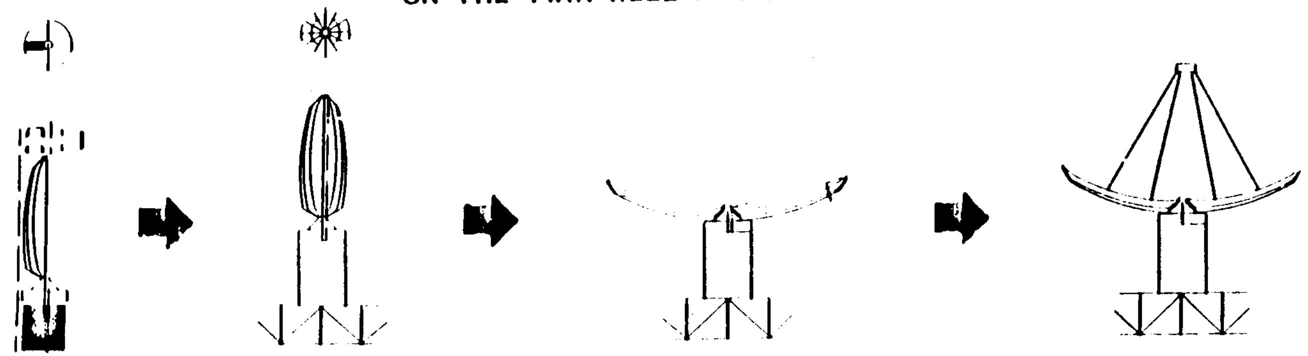
ON THE TWIN KEEL SPACE STATION



CREW FUNCTIONS	IVA	EVA	MRMS	MMU
• ASSEMBLE SUNSHADE BASE		X	X	X
• INSTALL SUNSHADE SIDE PANELS (6)		X	X	
• DEPLOY SUNSHADE SIDE PANELS	X			
• INTERCONNECT SUNSHADE SIDE PANELS		X	X	?
• PERFORM SUBSYSTEMS CHECKOUT	X			
• LOAD EXPENDABLES	X	X		
• REMOVE CONTAMINATION COVERS	?	X		?
• DEPLOY LDR, STATION KEEP	X			
• PERFORM LDR CHECKOUT	X			
• TRANSFER TO OPERATIONAL ORBIT	X			

LDR ASSEMBLY

ON THE TWIN KEEL SPACE STATION



CREW FUNCTIONS	IVA	EVA	MRMS	MMU
• UNLOAD COMPONENTS, TEMPORARILY STOW	X	B/U	X	
• POSITION FOR INSTALLATION	X	B/U	X	
• SET-UP ASSEMBLY SUPPORT EQUIPMENT		X	X	X
• ASSEMBLE LSR/STATION INTERFACE STRUCTURE		X	X	
• INSTALL LDR SUBSYSTEM MODULE		X	X	
• INSTALL MIRROR RIB ASSEMBLY ON SUBSYSTEM MODULE	X	X	X	
• DEPLOY RIBS		X	X	
• INSTALL RIB STIFFENERS		X	X	X
• INSTALL ENCAPSULATED MIRROR PANELS WITH STRONGBACK		X	X	
• INSTALL SECONDARY MIRROR		X	X	X

EXPERIMENT TITLE: LARGE DEPLOYABLE REFLECTOR

PROPOSED FLIGHT DATE - 1997 YEAR

OPERATIONAL DAYS REQUIRED - Not available (Assembly: Weeks; Servicing: days)

MASS - 30,000 KG

VOLUME:

STORED: W 4 x L 18 x H 4 = 288 M^3 (two package

DEPLOYED: W 25 x L 30 x H 25 = 1870 M^3

INTERNALLY ATTACHED no (YES/NO)
EXTERNALLY ATTACHED yes (YES/NO)
FORMATION FLYING no (YES/NO)

ORIENTATION (inertial, solar, earth, other) other

EXTRA-VEHICULAR ACTIVITY REQUIRED: Data not yet available

SET-UP: ____ Hrs/Day ____ No. of days

OPERATIONS: ____ Hrs/Day ____ No. of days ____ Interval

SERVICING: ____ Hrs/Day ____ No. of days ____ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED: Data not yet available

SET-UP: ____ Hrs/Day ____ No. of days

OPERATIONS: ____ Hrs/Day ____ No. of days ____ Interval

SERVICING: ____ Hrs/Day ____ No. of days ____ Interval

POWER REQUIRED:

5 KW AC or DC (circle one)

N/A Hrs/Day N/A No. of days

DATA RATE: N/A Megabits/second

DATA STORAGE: N/A Gigabits

TECHNOLOGY DEVELOPMENT MISSION FOR LARGE DEPLOYABLE REFLECTOR

DONALD L. AGNEW, EASTMAN KODAK COMPANY, GOVERNMENT SYSTEMS DIVISION, ROCHESTER, NY

EXPERIMENT OBJECTIVE

TO PROVIDE A TECHNOLOGY BASE FOR THE TRANSPORTATION, CONSTRUCTION, ALIGNMENT, TEST, AND OPERATION OF LARGE APERTURE SEGMENTED MIRRORS HAVING HIGH SURFACE ACCURACY OPTICAL FIGURES.

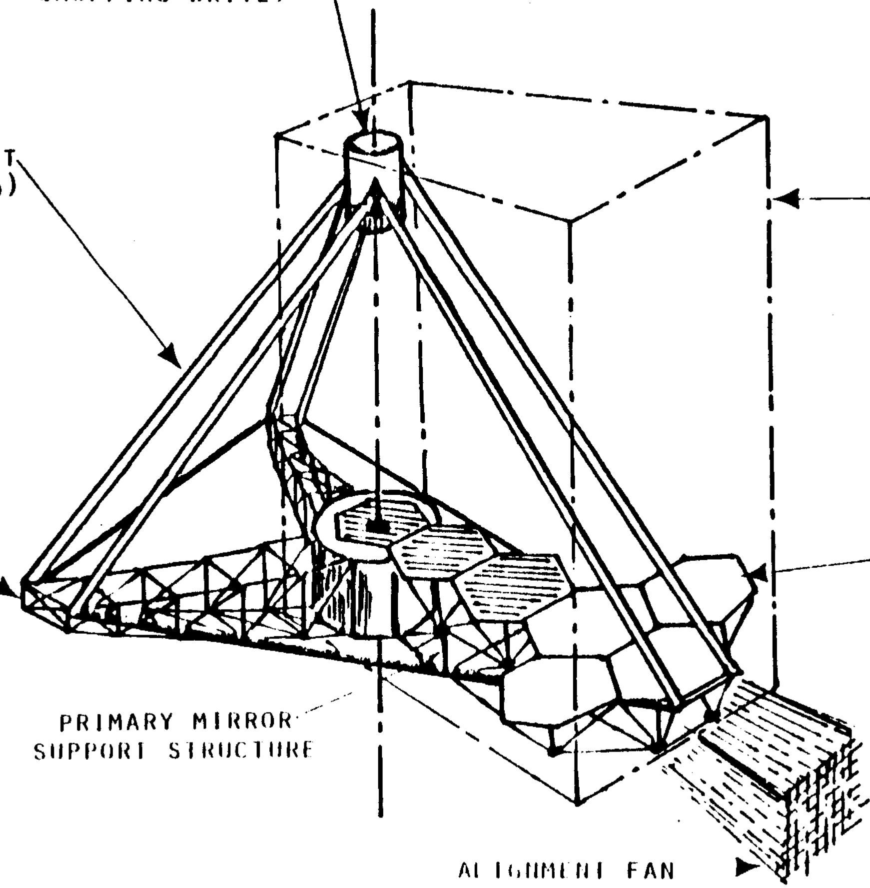
EXPERIMENT DESCRIPTION

THE PROPOSED MISSION WILL INVESTIGATE CRITICAL TECHNOLOGICAL ISSUES GERMANE TO USE OF LARGE, MULTI-SEGMENTED, ACTIVE REFLECTORS IN FUTURE SPACE PROJECTS. KEY AREAS OF EXPERIMENTATION ARE EFFICIENT DEPLOYMENT AND ERECTION OF SUPPORTING TRUSS STRUCTURE; VERIFYING HIGH RESISTANCE OF THE TRUSS STRUCTURE TO MICRO SCALE DEFORMATION DUE TO THERMAL OR VIBRATION EFFECTS; DEPLOYMENT AND LATCHING OF MIRROR ELEMENTS; MEASUREMENT OF OPTICAL ALIGNMENT THROUGH WAVEFRONT SENSING OR LASER RANGING TECHNIQUES; ADJUSTMENT OF MIRROR SEGMENTS THROUGH MICROACTUATORS AND CONTROL ALGORITHMS; DEMONSTRATION OF EFFECTIVE MEANS OF CONTAMINATION CONTROL AND THE EFFICACY OF SECONDARY MIRROR CHOPPING.

TECHNOLOGY DEVELOPMENT CONCEPT FOR LARGE DEPLOYABLE REFLECTOR

DONALD L. AGNEW, EASTMAN KODAK COMPANY, GOVERNMENT SYSTEMS DIVISION, ROCHESTER, NY

FULL SIZE SCALING



EXPERIMENT TITLE: Technology Development Mission for Large Deployable Reflector

Donald L. Agnew, Eastman Kodak Company, Government Systems Division, Rochester, New York 14650

PROPOSED FLIGHT DATE - 1995 **YEAR**

OPERATIONAL DAYS REQUIRED - 360

MASS 7500 **KG**

VOLUME:

STORED: **W** 4 **x L** 4 **x H** 18 **=** 288 M^3

DEPLOYED: **W** 18 **x L** 24 **x H** 15 **=** 6480 M^3

INTERNALLY ATTACHED NO **(YES/NO)**
EXTERNALLY ATTACHED YES **(YES/NO)**
FORMATION FLYING NO **(YES/NO)**

ORIENTATION (inertial, solar, earth, other) OTHER

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 8 **Hrs/Day** 20 **No. of days**

OPERATIONS: 2 **Hrs/Day** 1 **No. of days** 30 **Interval**

SERVICING: ____ **Hrs/Day** ____ **No. of days** ____ **Interval**

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 8 **Hrs/Day** 40 **No. of days**

OPERATIONS: 8 **Hrs/Day** 1 **No. of days** 10 **Interval**

SERVICING: 1 **Hrs/Day** 1 **No. of days** 30 **Interval**

POWER REQUIRED:

1 **KW** **AC or DC (circle one)**

8 **Hrs/Day** 50 **No. of days**

DATA RATE: 0.2 **Megabits/second**

DATA STORAGE: 1 **Gigabits**

STRUCTURAL CONCEPTS RESEARCH FACILITY

OBJECTIVE: SPACE STATION FACILITY TO INVESTIGATE NEW STRUCTURAL CONCEPTS FOR FUTURE SPACECRAFT.

DESCRIPTION: USE THE SPACE STATION TO DEVELOP AND TEST NEW STRUCTURAL DESIGNS AND TECHNIQUES, SUCH AS:

1) ON ORBIT VACUUM CURING OF COMPOSITES
2) INFLATED STRUCTURES
3) VAPOR DEPOSITION
4) ROTATING STRUCTURES
5) WIRE BRACING
6) ON ORBIT STRUCTURAL REPAIRS

EXPERIMENT TITLE: STRUCTURAL CONCEPT RESEARCH FACILITY

PROPOSED FLIGHT DATE - IOC + 2 YR YEAR

OPERATIONAL DAYS REQUIRED - PERM FAC.

MASS - 500 - 1000 KG

E F CRAWLEY
37-341 MIT
CAMBRIDGE MA
02139
617-253-7510

VOLUME:

STORED W 5 x L 5 x H 2 = 50 M^3

DEPLOYED W 5 x L 10 x H 5 = 250 M^3

INTERNALLY ATTACHED ____ (YES/NO)
EXTERNALLY ATTACHED Y (YES/NO)
FORMATION FLYING ____ (YES/NO)

ORIENTATION (inertial, solar, earth, other) N/A

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ____ Hrs/Day ____ No. of days

OPERATIONS: ____ Hrs/Day ____ No. of days ____ Interval

SERVICING 2 Hrs/Day 20 No. of days / year Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ____ Hrs/Day ____ No. of days

OPERATIONS: ____ Hrs/Day ____ No. of days ____ Interval

SERVICING ____ Hrs/Day ____ No. of days ____ Interval

POWER REQUIRED:

1-3 KW AC or DC (circle one)

4 Hrs/Day ____ ~~No. of days~~ occasionally

DATA RATE: ____ Megabits/second

DATA STORAGE: ____ Gigabits

not critical

MICRO-METEORITE PROTECTION

OBJECTIVE: INVESTIGATION OF NEW TECHNIQUES OF MICROMETEORITE PROTECTION

DESCRIPTION: TESTING NEW CONCEPTS IN MICROMETEORITE PROTECTION, USING THE MICROMETEORITE ENVIRONMENT OF THE SPACE STATION

EXPERIMENT TITLE: Micro Metiorite Protection Development

SF Crawley
37-341 MIT
Cambridge MA
02139
617-253-7510

PROPOSED FLIGHT DATE - IOC + 3 YR YEAR

OPERATIONAL DAYS REQUIRED - Semi permanent

MASS - 2000 KG

VOLUME:

STORED W ~~10~~ 5 x L ~~10~~ 5 x H ~~1~~ 4 = 100 M^3

DEPLOYED W 10 x L 10 x H 1 = 100 M^3

INTERNALLY ATTACHED ______ (YES/NO)
EXTERNALLY ATTACHED X (YES/NO)
FORMATION FLYING ______ (YES/NO)

ORIENTATION (inertial, solar, earth, other) anti earth

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 1 Hrs/Day 1 No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ____ Interval

SERVICING ______ Hrs/Day ______ No. of days ____ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ____ Interval

SERVICING ______ Hrs/Day ______ No. of days ____ Interval

POWER REQUIRED:

None ______ KW AC or DC (circle one)

______ Hrs/Day ______ No. of days

DATA RATE: ______ Megabits/second

DATA STORAGE: ______ Gigabits

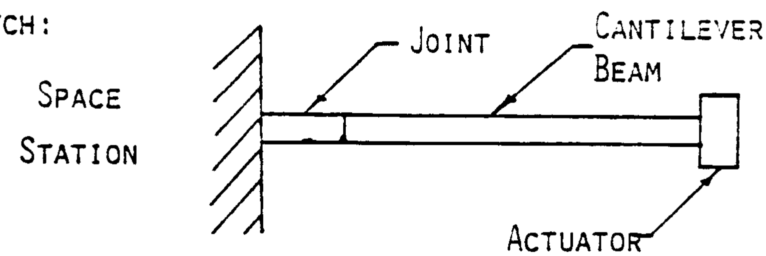
ENVIRONMENTAL INFLUENCE ON STRUCTURAL DYNAMICS

OBJECTIVE: INVESTIGATE THE LONG TERM EFFECTS OF THE ORBITAL ENVIRONMENT ON MATERIALS IN FRICTIONAL CONTACT WITHIN JOINTS AND OTHER SURFACES IN CONTACT

DESCRIPTION: DATA ON CHANGES IN JOINT BEHAVIOR DUE TO WEAR, COLD WELDING, ETC., WILL BE OF GREAT IMPORTANCE TO SPACECRAFT DESIGNERS. A LONG DURATION EXPERIMENT IS PROPOSED TO EXPOSE JOINTS TO:

1) DIFFERENT LOADING CONDITIONS
2) SPACE VACUUM ENVIRONMENT
3) SPACE THERMAL ENVIRONMENT
4) LONG DURATION MICROSLIP WEAR

SKETCH:



DATA COLLECTED FROM STRAIN GAGES AND ACCELEROMETERS ATTACHED TO THE JOINT AND THE BEAM.

~~SPACE~~ ENVIRONMENTAL INFLUENCE ON

EXPERIMENT TITLE: STRUCTURAL ~~CONTACT~~ SURFACES

ED CRAWLEY
37-341 MIT
CAMBRIDGE MA
02139
617-253-7510

PROPOSED FLIGHT DATE - IOC + 2YR YEAR

OPERATIONAL DAYS REQUIRED - 2-3 YR

MASS - 200 KG

VOLUME:

STORED W 2 x L 2 x H 5 = 20 M^3

DEPLOYED W 2 x L 2 x H 5 = 20 M^3

INTERNALLY ATTACHED ______ (YES/NO)
EXTERNALLY ATTACHED Y (YES/NO)
FORMATION FLYING ______ (YES/NO)

ORIENTATION (inertial, solar, earth, other) NA

EXTRA-VEHICULAR ~~ACTIVITY REQUIRED:~~ at start automated

SET-UP: 2 Hrs/Day 1 No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ____ Interval

SERVICING ______ Hrs/Day ______ No. of days ____ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ____ Interval

SERVICING ______ Hrs/Day ______ No. of days ____ Interval

POWER REQUIRED:

.5 KW AC or DC (circle one)

______ Hrs/Day ______ No. of days

DATA RATE: ______ Megabits/second } not critical

DATA STORAGE: ______ Gigabits

POLYMERIC MATERIALS FOR SPACE MECHANISMS

OBJECTIVE: DETERMINE SPACE EXPOSURE LONG TERM EFFECT ON TRIBOLOGICAL PERFORMANCE (WEAR, FRICTION, ETC.) OF SELF-LUBRICATING POLYMERIC MATERIALS UNDER SLIDING/ROLLING CONTACT FOR SPACE MECHANISMS.

JUSTIFICATION: CRITICAL NEED FOR SPACE QUALIFIED, SELF-LUBRICATING MATERIALS FOR SPACE MECHANISM JOINTS. ATOMIC OXYGEN, UV RADIATION, THERMAL CYCLING, DIFFICULT TO SIMULATE.

S. LOEWENTHAL
NASA LEWIS RESEARCH CENTER

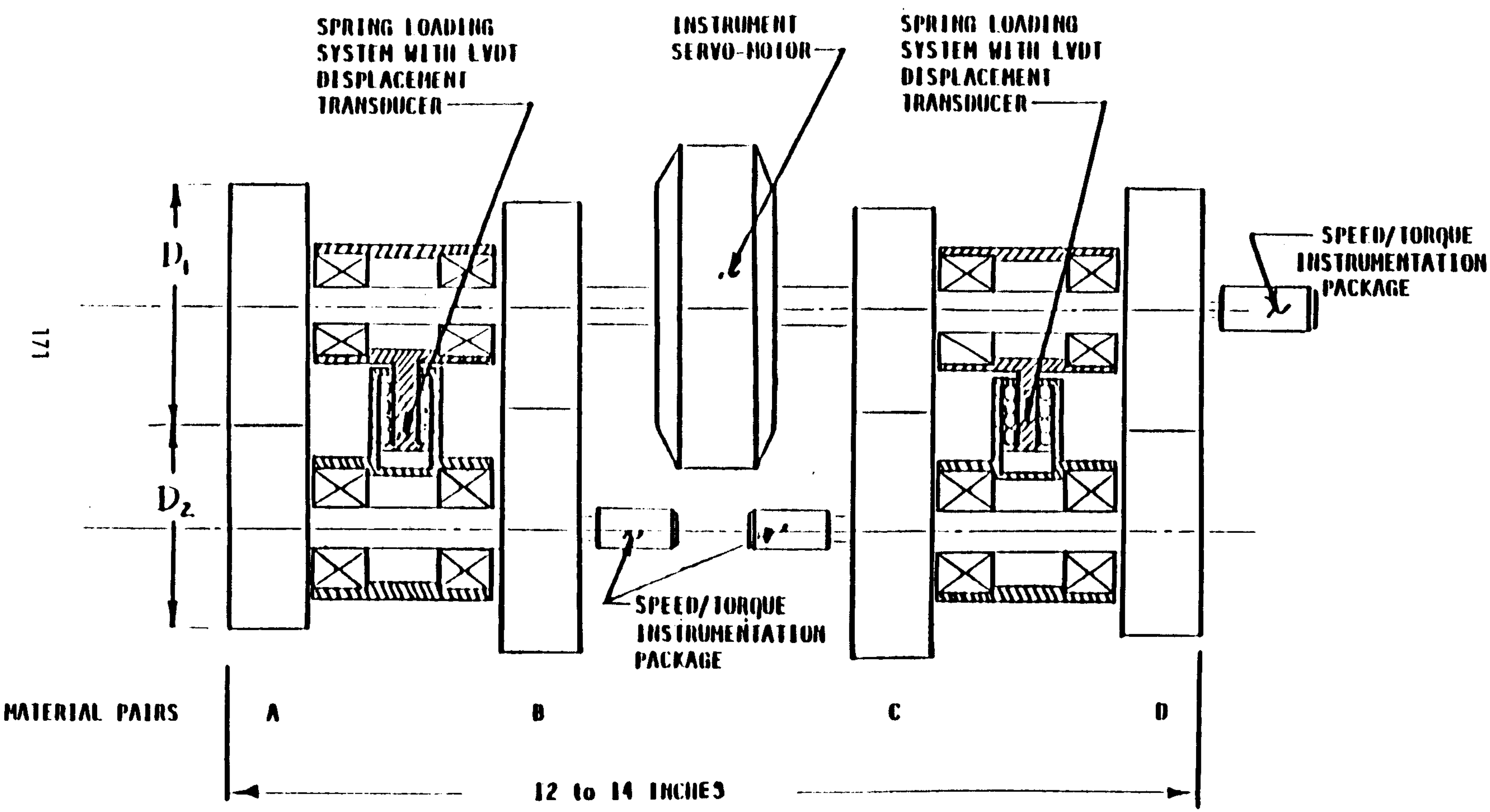
POLYMERIC MATERIALS FOR SPACE MECHANISMS

DESCRIPTION:

- o MULTIPLE ROLLER PAIRS (4 TO 8) DRIVEN IN SLIDING/ROLLING CONTACT BY SINGLE SERVO-MOTOR.
- o SLIDE/ROLL RATIOS DICTATED BY ROLLER DIAMETER MISMATCHED.
- o LOAD LEVELS IMPOSED BY SPRINGS.
- o WEAR RATES AND FRICTION LEVELS MEASURED IN SITU BY FORCE AND DISPLACEMENT SENSORS.
- o PERFORMANCE CORRELATED IN REAL TIME AGAINST ATMO$_2$, UV, TEMPERATURE, ETC.
- o OUTGASSING CHARACTERISTICS DETERMINED.
- o PERIODIC DATA SAMPLING.

S. LOEWENTHAL
NASA LEWIS RESEARCH CENTER

POLYMERIC MATERIALS SPACE EXPOSURE EXPERIMENT



S. LOEWENTHAL
NASA LEWIS RESEARCH CENTER

EXPERIMENT TITLE: Polymeric Materials for Space Mechanisms

PROPOSED FLIGHT DATE - 1989 YEAR

OPERATIONAL DAYS REQUIRED - 180

MASS - 6 KG

VOLUME:

STORED: W .13 x L .41 x H .23 = .012 M^3

DEPLOYED: W .19 x L .41 x H .23 = .018 M^3

INTERNALLY ATTACHED No (YES/NO)
EXTERNALLY ATTACHED Yes (YES/NO)
FORMATION FLYING No (YES/NO)

ORIENTATION (inertial, solar, earth, other) Solar

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 0 Hrs/Day ____ No. of days

OPERATIONS: 0.2 Hrs/Day 180 No. of days 1 hr Intervals
(automatic)
SERVICING: 0 Hrs/Day ____ No. of days ____ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 0 Hrs/Day ____ No. of days

OPERATIONS: 0 Hrs/Day ____ No. of days ____ Interval

SERVICING: 0 Hrs/Day ____ No. of days ____ Interval

POWER REQUIRED:

0.05 KW AC or DC (circle one)

24 Hrs/Day 90 No. of days

DATA RATE: 0.001 Megabits/second

DATA STORAGE: 0.5 Gigabits

Stuart H. Loewenthal
NASA Lewis Research Center

BERTHING AND DOCKING SENSOR

WILFRED OTAGURO — MDAC/JSC
HARRY ERWIN

OBJECTIVE: DEMONSTRATE A BERTHING AND DOCKING SCENARIO TO EVALUATE CANDIDATE B&D SENSORS ON A SPACE SHUTTLE FLIGHT

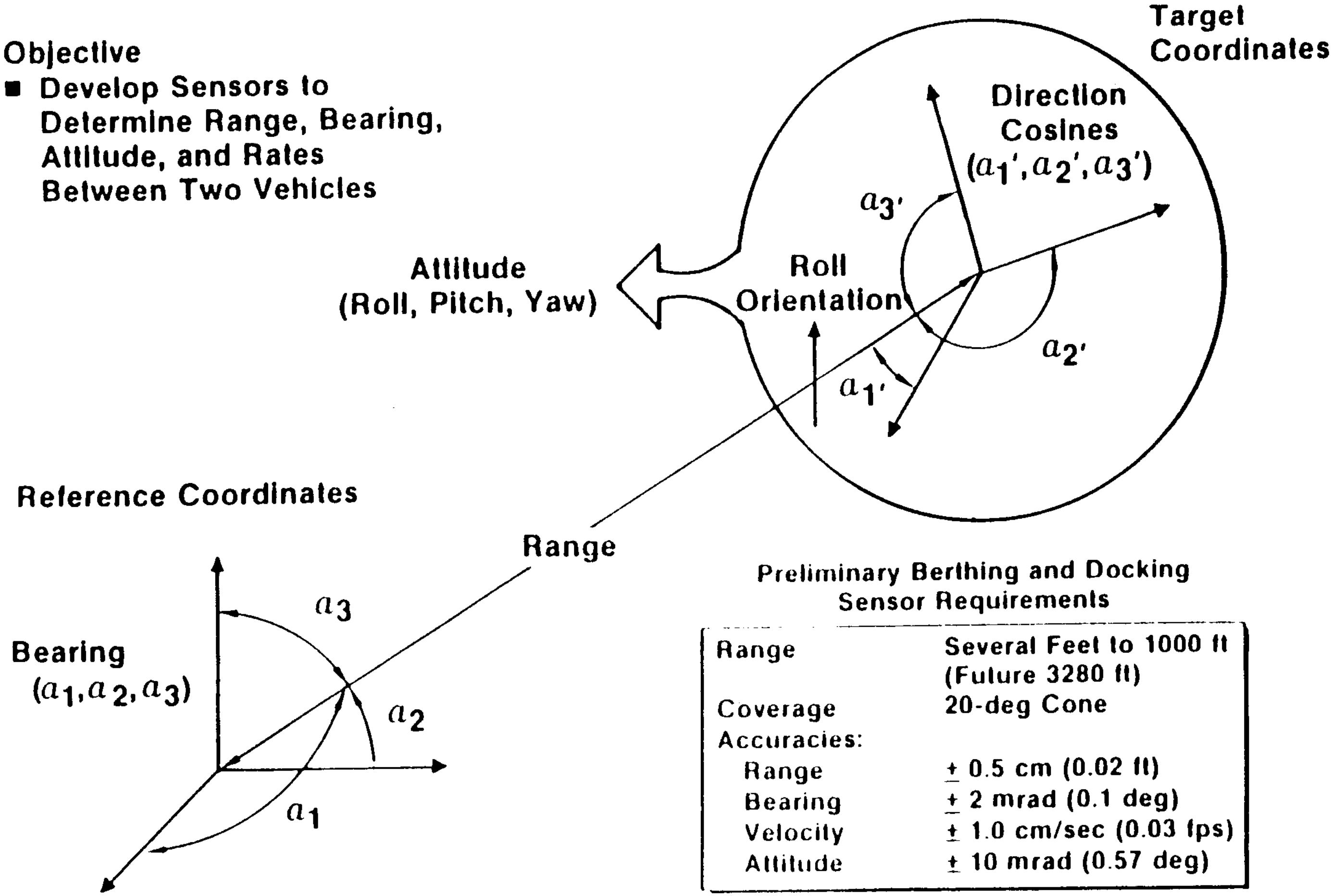
APPROACH: DEVELOP A B&D SENSOR FOR DEVELOPMENT FOR A SHUTTLE DEMONSTRATION BASED ON GROUND TEST RESULTS IN '86 AT JSC.

BERTHING AND DOCKING SENSORS

VHC156

Objective

- Develop Sensors to Determine Range, Bearing, Attitude, and Rates Between Two Vehicles

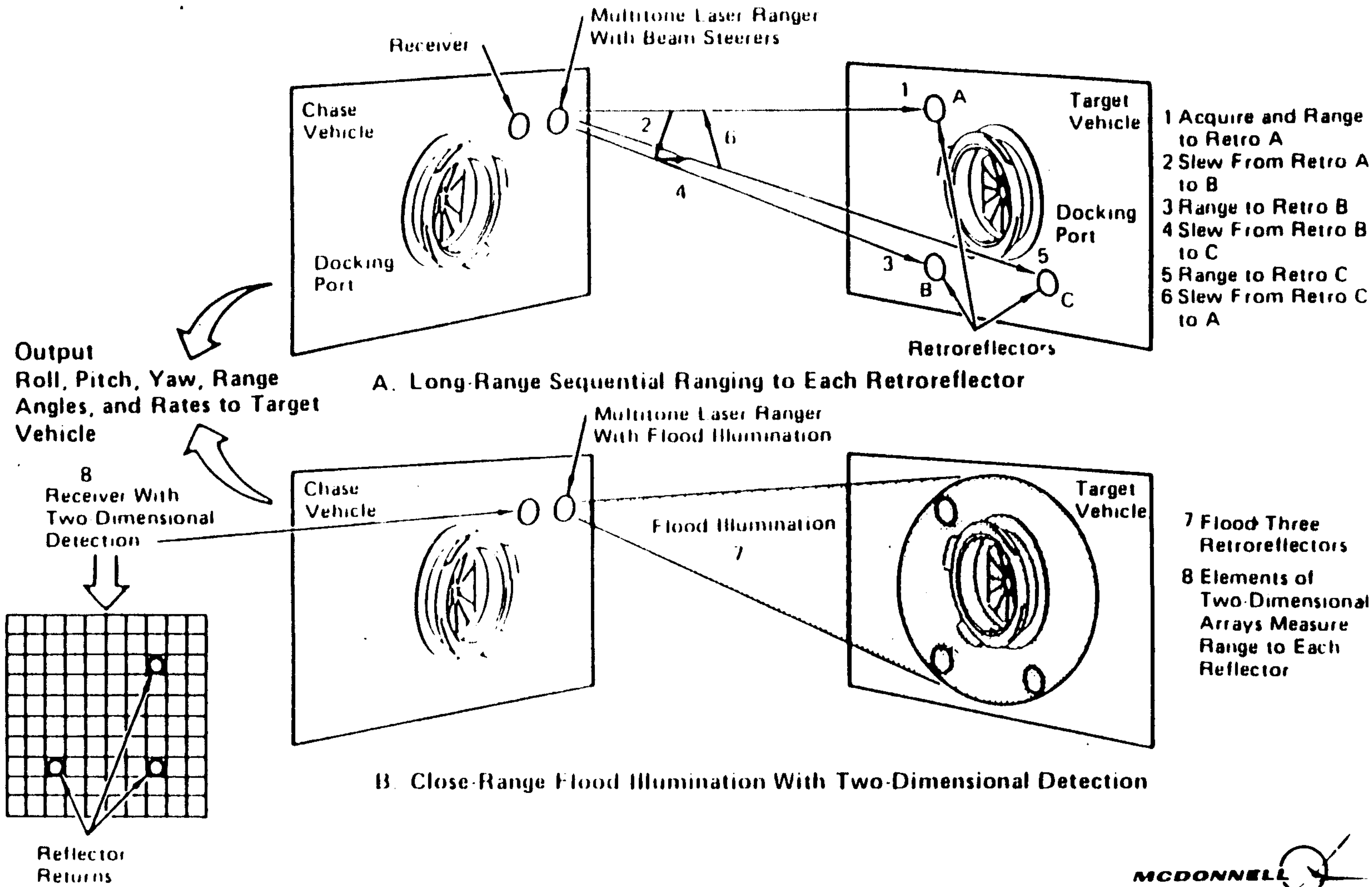


Preliminary Berthing and Docking Sensor Requirements

Range	Several Feet to 1000 ft (Future 3280 ft)
Coverage	20-deg Cone
Accuracies:	
Range	± 0.5 cm (0.02 ft)
Bearing	± 2 mrad (0.1 deg)
Velocity	± 1.0 cm/sec (0.03 fps)
Attitude	± 10 mrad (0.57 deg)

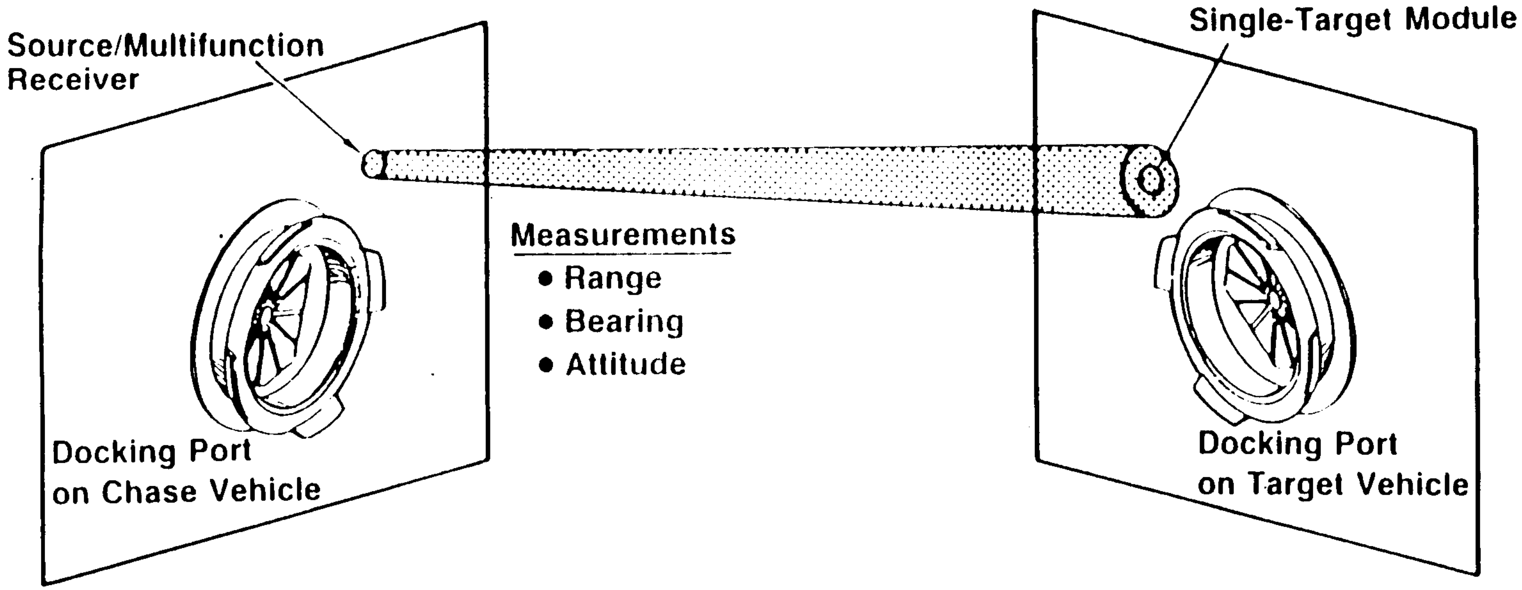
THREE RETROREFLECTOR CONCEPT
NASA STRAWMAN

VGY473



MCDONNELL DOUGLAS

SINGLE TARGET MODULE CONCEPT



EXPERIMENT TITLE: BERTHING AND DOCKING SENSOR

PROPOSED FLIGHT DATE - 1987-88 YEAR

OPERATIONAL DAYS REQUIRED - ONE

MASS - 40 KG

VOLUME:

STORED W ______ x L ______ x H ______ = 0.5 M^3

DEPLOYED W ______ x L ______ x H ______ = 0.5 M^3

INTERNALLY ATTACHED ______ (YES/NO)
EXTERNALLY ATTACHED ______ (YES/NO)
FORMATION FLYING ______ (YES/NO)

ORIENTATION (inertial, solar, earth, other) ______

EXTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: 2 Hrs/Day ONE No. of days

OPERATIONS: 6 Hrs/Day ONE No. of days ____ Interval

SERVICING ______ Hrs/Day ______ No. of days ____ Interval

INTRA-VEHICULAR ACTIVITY REQUIRED:

SET-UP: ______ Hrs/Day ______ No. of days

OPERATIONS: ______ Hrs/Day ______ No. of days ____ Interval

SERVICING ______ Hrs/Day ______ No. of days ____ Interval

POWER REQUIRED:

0.2 KW AC or DC (circle one)

AS NEEDED Hrs/Day ______ No. of days

DATA RATE: ______ Megabits/second

DATA STORAGE: ______ Gigabits

ASSEMBLY CONCEPT FOR CONSTRUCTION OF ERECTABLE SPACE STRUCTURE

Walter (Doug) Heard

Principal Investigator

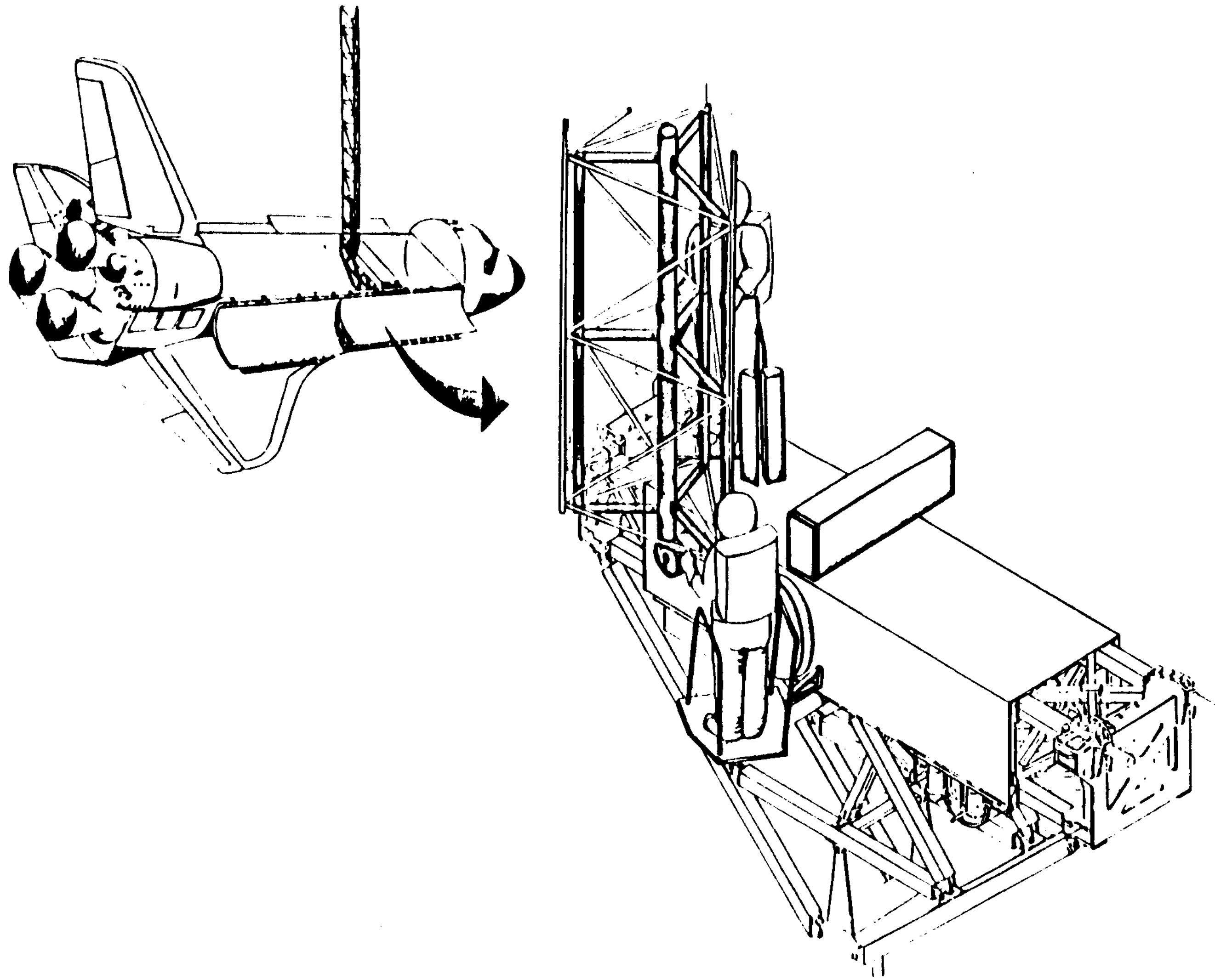
NASA, Langley Research Center

In-Space Research, Technology & Engineering Workshop

Williamsburg, Virginia

October 8-10, 1985

ACCESS
ASSEMBLY CONCEPT FOR CONSTRUCTION OF ERECTABLE SPACE STRUCTURE



OUTLINE

- ACCESS FLIGHT EXPERIMENT
  - BASELINE
  - EXPANDED
  - STATUS
- NEUTRAL BUOYANCY (SIMULATED 0-G) TESTS
  - BASELINE
  - EXPANDED
- FOLLOW-ON ACTIVITY
- CONCLUDING REMARKS

BASELINE ACCESS FLIGHT EXPERIMENT

PURPOSE: TO EVALUATE A CONCEPT FOR EFFICIENT EVA MANUAL ASSEMBLY OF SPACE STRUCTURE

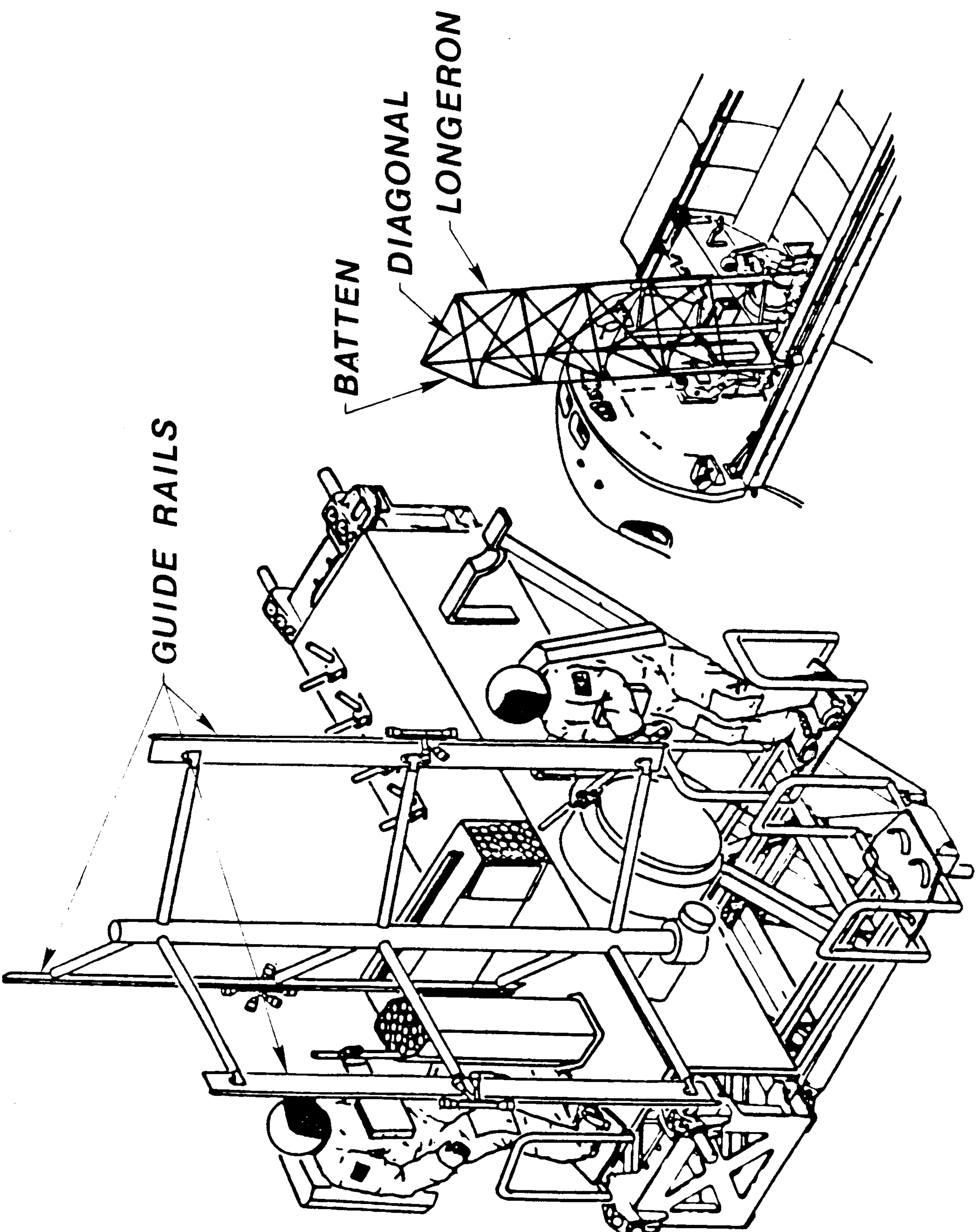
OBJECTIVES:

CORRELATION OF ORBITAL ASSEMBLY RATES AND TECHNIQUES WITH WITH GROUND TEST DATA

GAIN ON-ORBIT CONSTRUCTION EXPERIENCE

IDENTIFY ASSEMBLY TECHNIQUES TO IMPROVE ERECTABLE STRUCTURES PRODUCTIVITY: RELIABILITY: AND SAFETY

APPROACH: FIXED FOOT RESTRAINTS (WORK STATIONS) WITH ROTATING ASSEMBLY FIXTURE



GUIDE RAILS
BATTEN
DIAGONAL
LONGERON

EXPANDED ACCESS EXPERIMENT

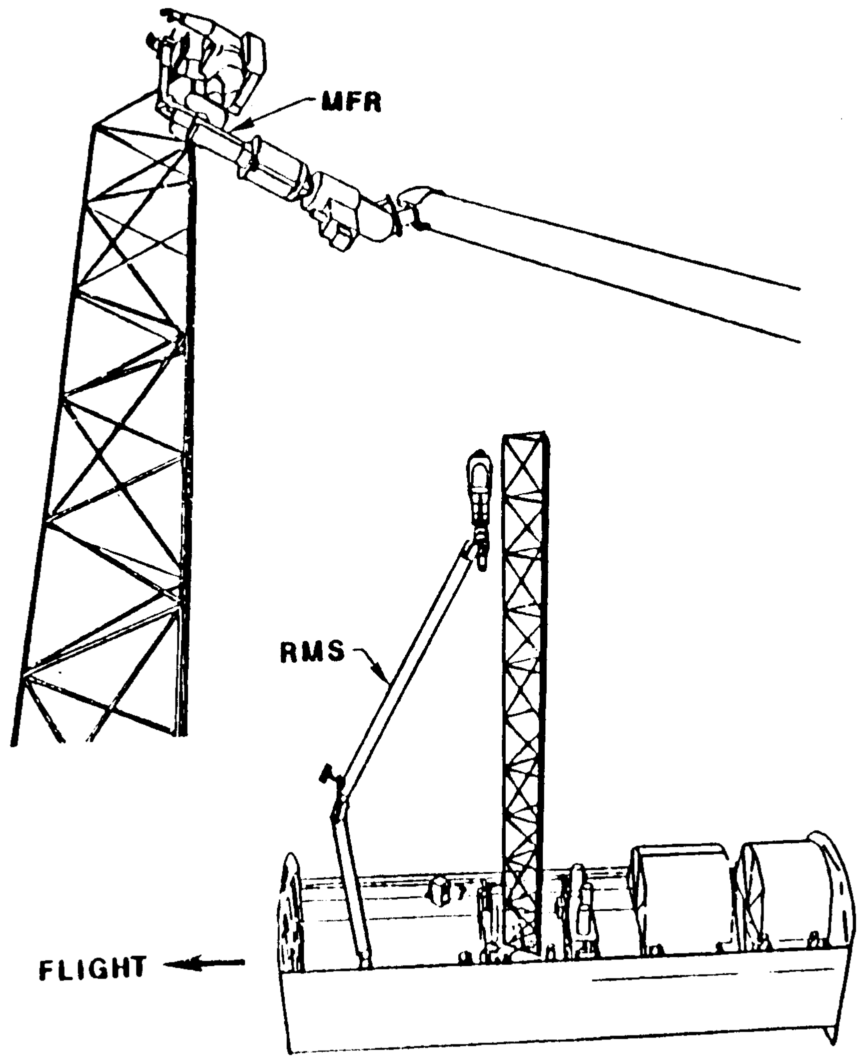
PURPOSE: TO EVALUATE PROPOSED ASSEMBLY AND MAINTENANCE CONCEPTS AND TECHNIQUES IN SUPPORT OF SPACE STATION DEVELOPMENT

OBJECTIVES:

- STRUCTURAL ASSEMBLY
- STRUCTURAL REPAIR
- FLEXIBLE CABLE ATTACHMENT
- LARGE STRUCTURE MANIPULATION

APPROACH: EVA USING RMS-MFR

ACCESS EXPANDED EXPERIMENT



ACCESS EXPANDED EXPERIMENT

Setup
Build 9 bays (BASELINE)

Assemble 10th bay

Install/remove cable

Manipulate truss

Interchange work stations

Structural repair

Manipulate truss

Disassemble 10th bay

Assemble 10th bay

Stow & close up (BASELINE)

FLIGHT STATUS

FLIGHT - 61 B

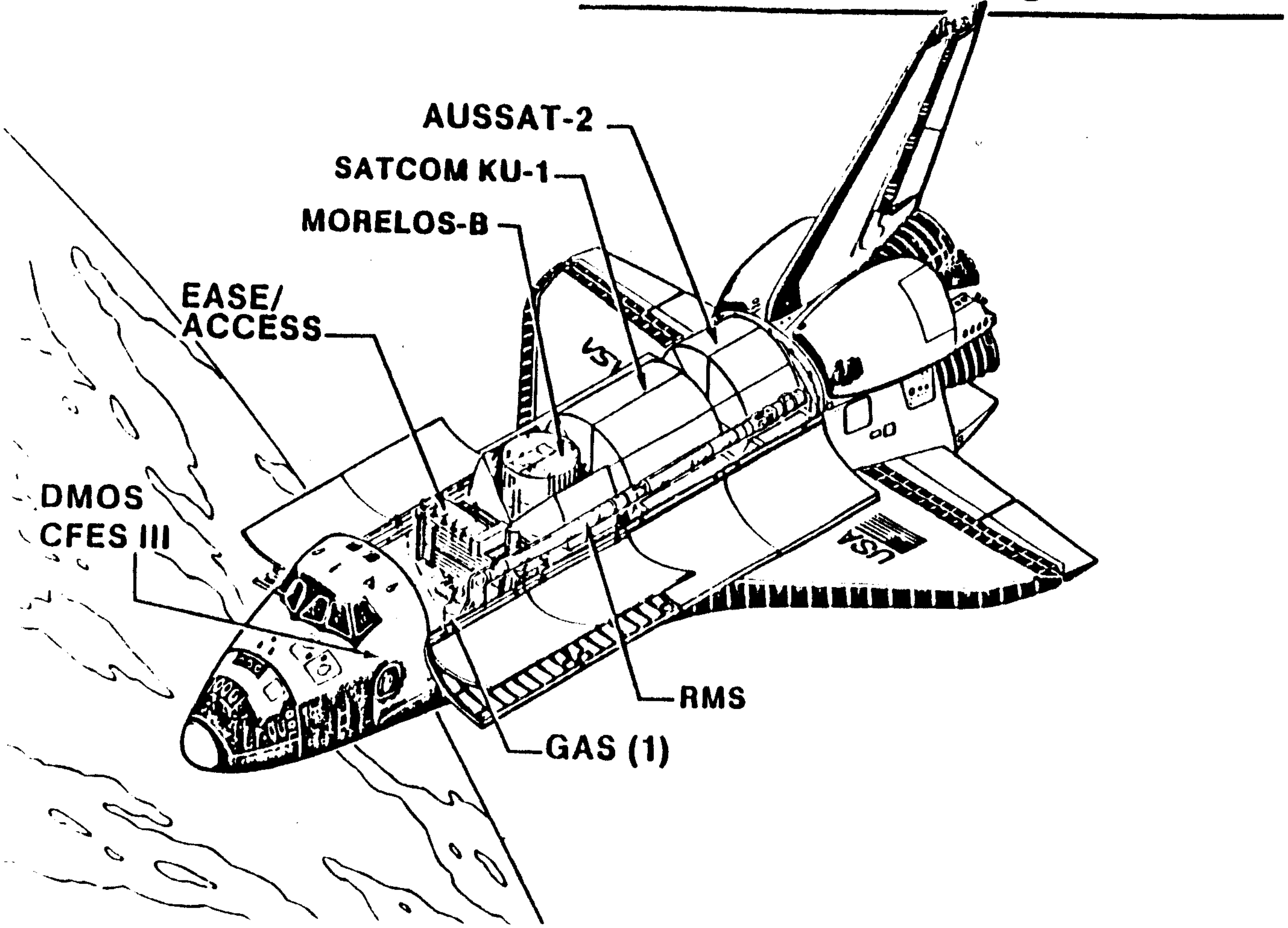
LAUNCH - NOVEMBER 27, 1985

CREW:

- BREWSTER SHAW, COMMANDER
- BRYAN O'CONNOR, PILOT
- MARY CLEAVE, MISSION SPECIALIST (RMS)
- JERRY ROSS, MISSION SPECIALIST (EVA)
- WOODY SPRING, MISSION SPECIALIST (EVA)
- TWO PAYLOAD SPECIALISTS

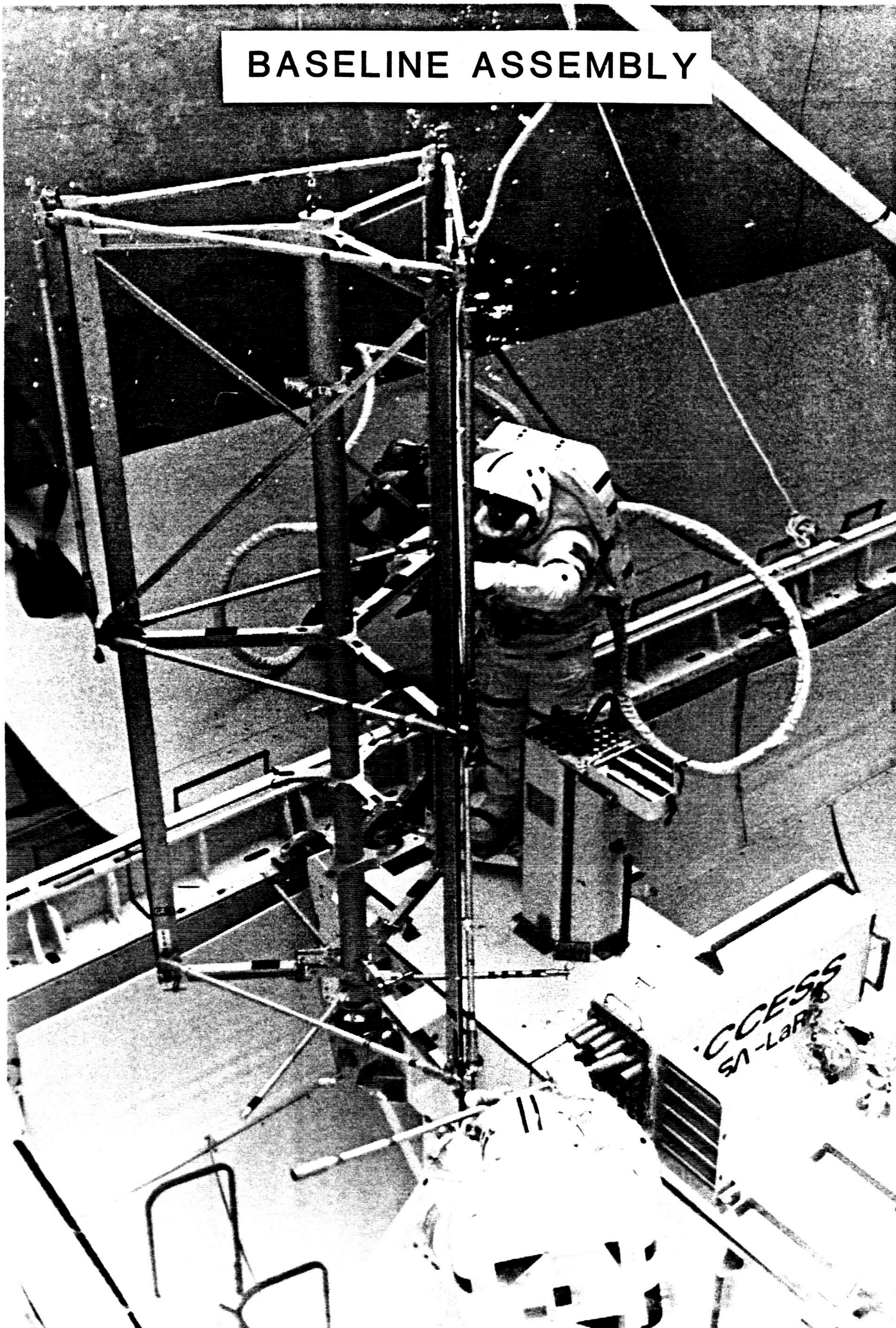
NASA
S-85-00302B

National STS Program
STS 61-B Cargo Configuration



NEUTRAL BUOYANCY TESTING RESULTS

ASSEMBLY FIXTURE DEPLOYMENT


BASELINE ASSEMBLY
CCESS

CONNECTION OF STRUT TO NODAL JOINT

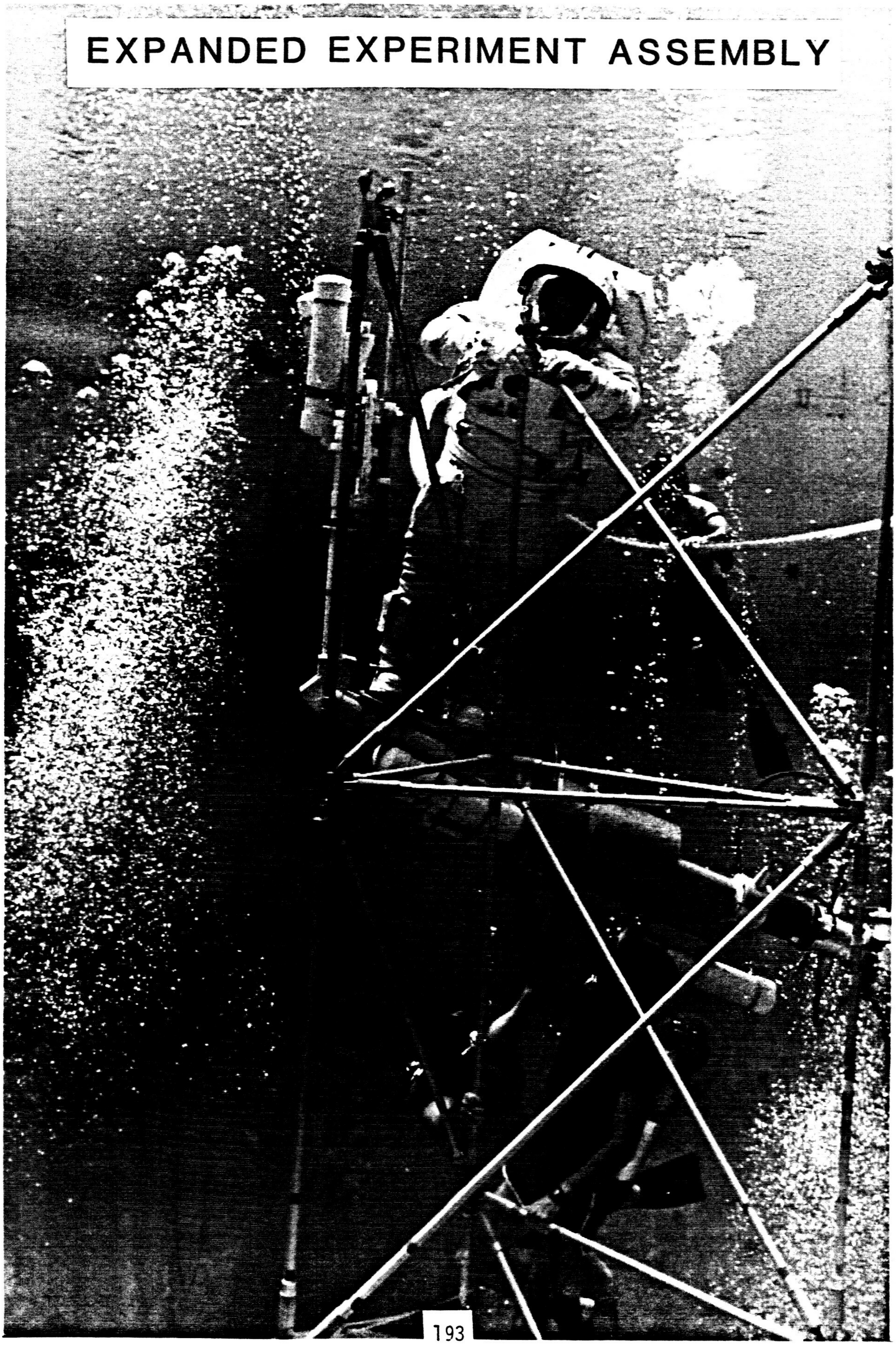
ACCESS BASELINE EXPERIMENT

TIMES FROM NEUTRAL BUOYANCY TESTS

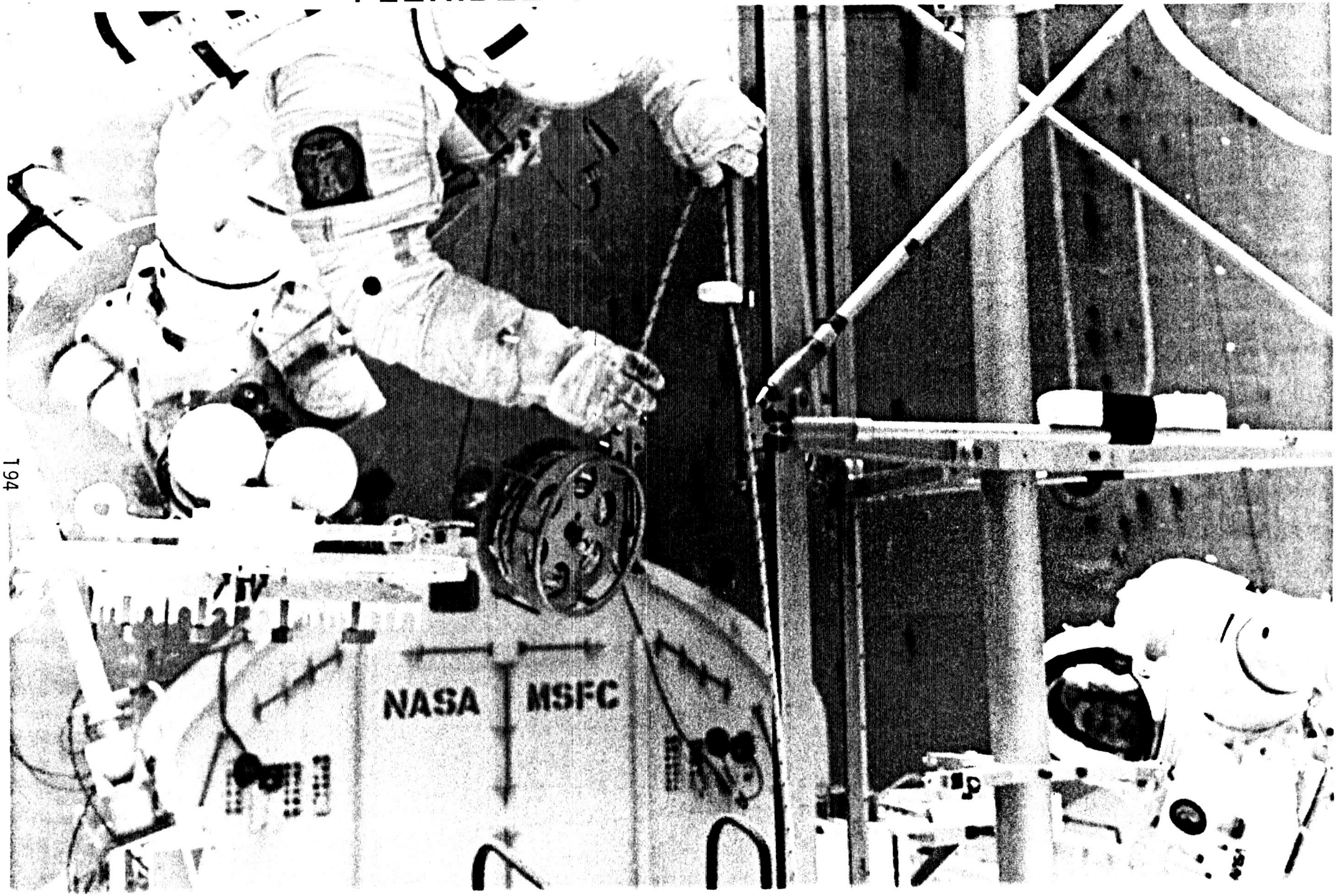
TASK	TIME (Min:sec)
Setup	4:00
Assemble 10 bays	30:13
Disassemble 10 bays	18:45
Stow & close up	5:23
Total	58:21

EVA time for flight: 2 hrs 15 min

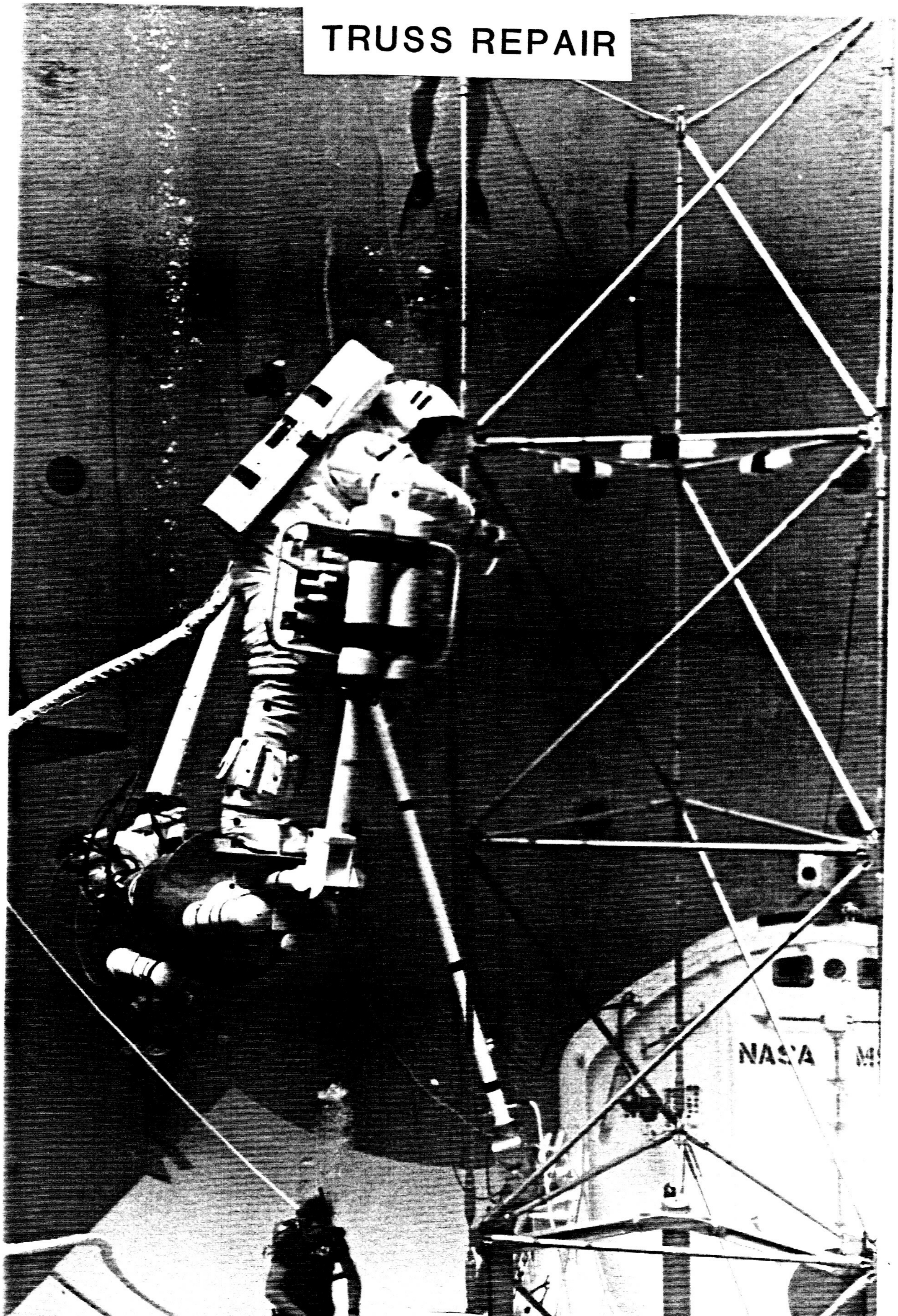
EXPANDED EXPERIMENT ASSEMBLY



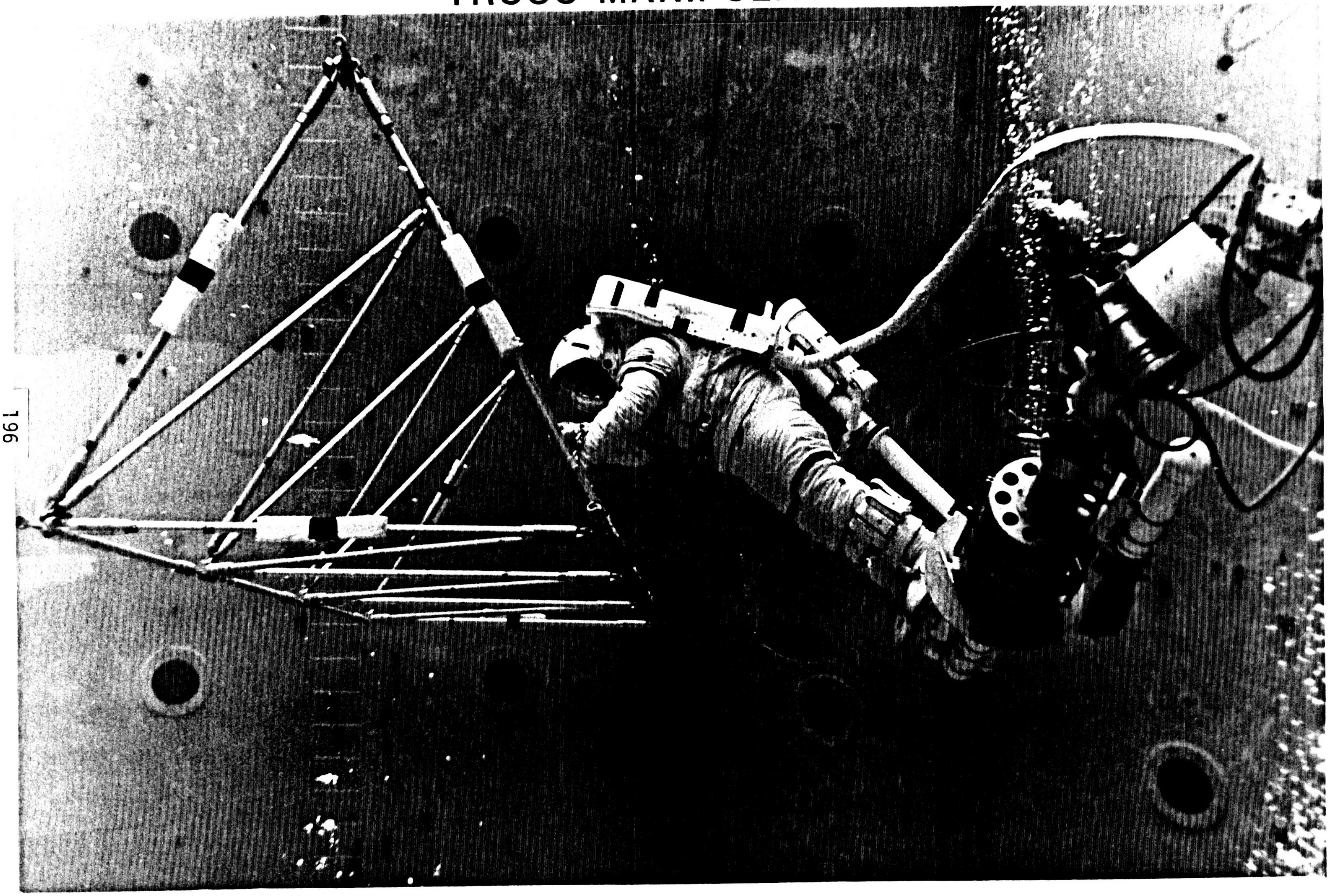
FLEXIBLE CABLE INSTALLATION



TRUSS REPAIR



TRUSS MANIPULATION



ACCESS EXPANDED EXPERIMENT

TIMES FROM NEUTRAL BUOYANCY TESTS

TASK	TIME (min:sec)
MFR Assembly/Disassembly (One bay)	9:10
Repair Activity	6:07
Cable Installation/Removal	16:51
Truss Manipulation	8:50

Total EXPANDED Experiment 1 hr 55 min

EVA time for flight: 3 hrs 25 min

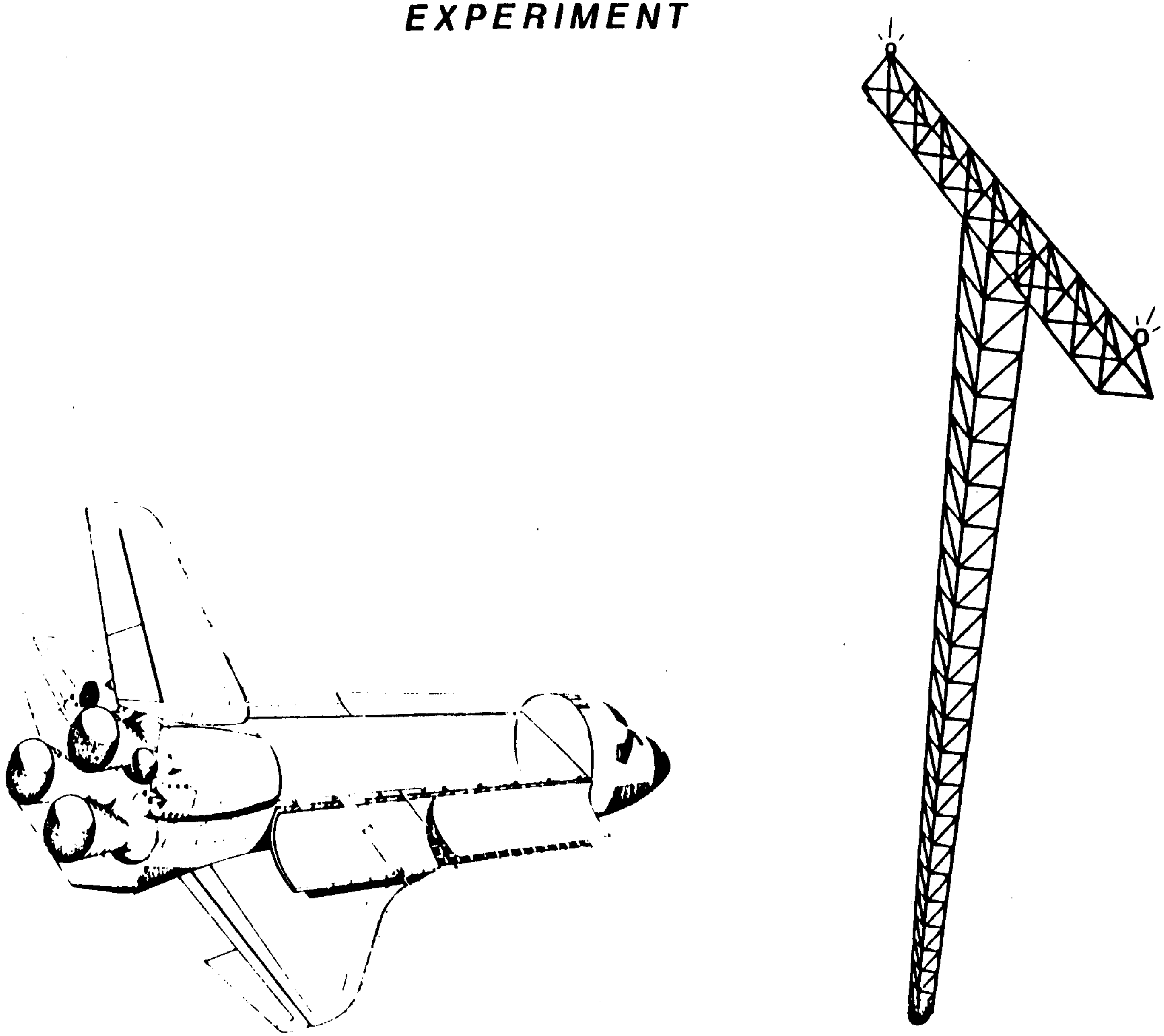
FOLLOW-ON ACTIVITY

SPACE CONSTRUCTION CONCEPTS DEMONSTRATION

OBJECTIVES:

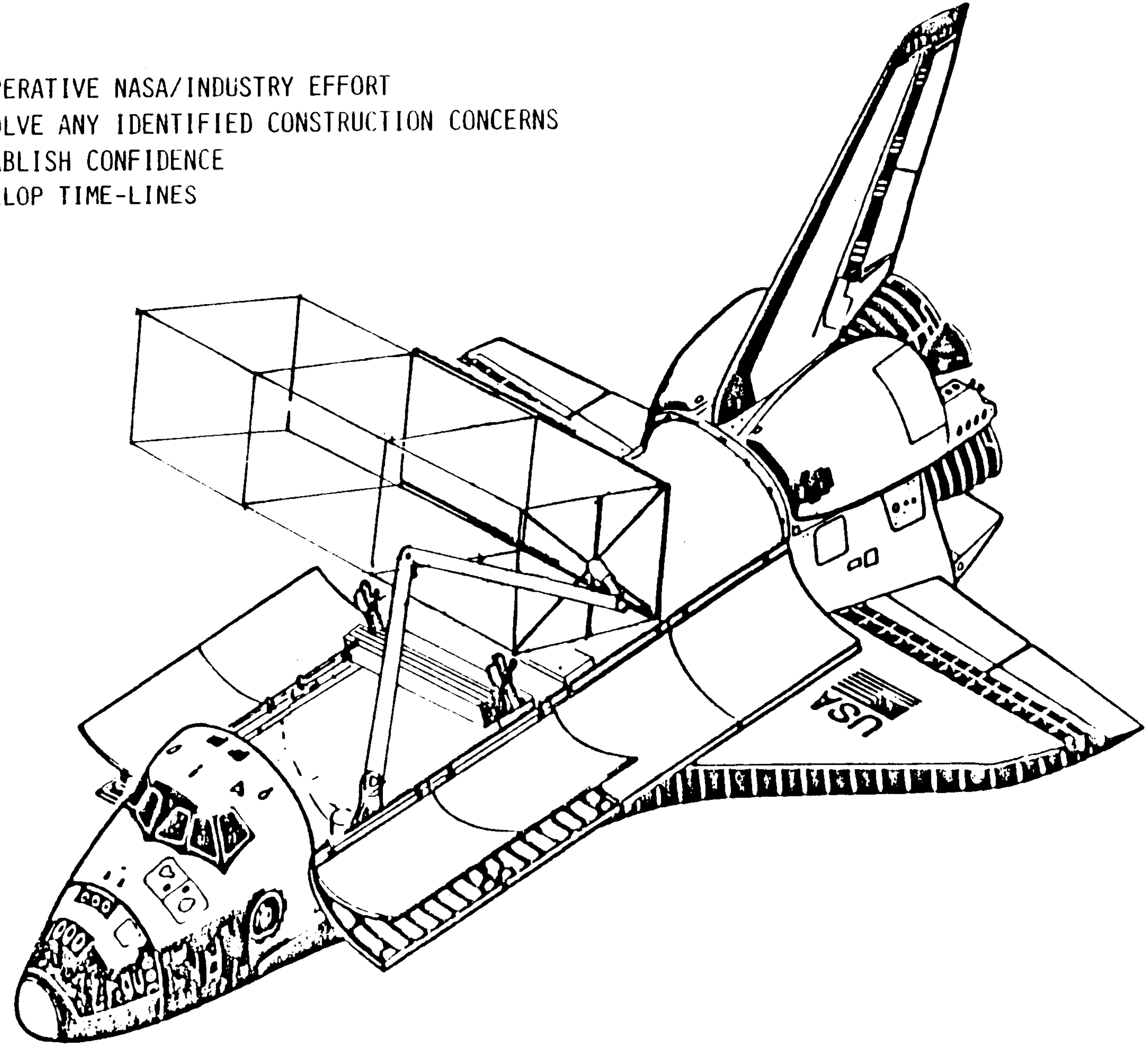
- Demonstrate with EVA hybrid modular assembly concepts using both erectable and deployable structures
- Demonstrate with EVA utility, instrument installation, and on-orbit integration
- Verify the operation of double-fold deployable truss structure
- Investigate passive stabilization of a free flying truss with pre-installed utilities

SPACE CONSTRUCTION DEMONSTRATION EXPERIMENT



ERECTABLE TRUSS FLIGHT EXPERIMENT BEING STUDIED

-- COOPERATIVE NASA/INDUSTRY EFFORT
-- RESOLVE ANY IDENTIFIED CONSTRUCTION CONCERNS
-- ESTABLISH CONFIDENCE
-- DEVELOP TIME-LINES



CONCLUDING REMARKS

ACCESS

- ASSEMBLY PROCEDURES AND HARDWARE EVALUATED BY FLIGHT CREW IN NB TESTS--ACCEPTABLE FOR FLIGHT
- TIMELINES GENERATED IN NB TESTS FOR CORRELATION WITH FLIGHT DATA
- FLIGHT HARDWARE DELIVERED TO KSC--READY FOR FLIGHT

FOLLOW-ON ACTIVITY

- PROPOSED DEMONSTRATION EXPERIMENTS ADDRESS KEY AREAS OF SPACE STATION CONSTRUCTION